

# Introduced Mammals and Their Influence on Native Biota<sup>1</sup>

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(Text-figure 1)

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## INTRODUCTION

IT is characteristic of man to alter his environment, and he has attempted in various ways to improve upon the conditions of nature. Unfortunately some attempts, such as indiscriminate deforestation and draining of swamps, have had bad effects. The ruthless extermination of many forms of plants and animals, or their uncontrolled introduction into new environments, also fall into this category.

In recent years the faulty reasoning behind the introduction of animals has become increasingly apparent. Biologists now are generally opposing the liberation of exotics into the wild, because of the unpredictable nature and possibly unfavorable economic consequences of such action, and because of an aesthetic objection to mixing diverse faunas. In compiling the present data on introduced mammals our aim is to elucidate the results of this practice and to clarify certain principles involved.

Introductions may be classified as intentional or unintentional. Prior to and during the early stages of colonization of many parts of the world, most exotics were imported unintentionally, as "chance" introductions, for example as stowaways on ships. Intentional introductions, for the purpose of establishing foreign species in a new territory, reached a peak during the Nineteenth Century. This paper deals mainly with the intentional introduction of wild mammals. Some information is presented concerning feral mammals, but introduced domestic species are not discussed.

Although the majority of introductions of mammals have failed, most of those which succeeded have proved detrimental to man's interests; only a few have been advantageous. The most serious problem is that of predicting the consequences of an introduction. The exotic only rarely will occupy the niche which the introducer expects it to fill.

The expense involved in introducing a species and getting it established is usually very high and has proved to be a poor investment in most cases. From the economic viewpoint, it is often more practical to foster an increase of native mammals as a means of attaining the desired results.

By and large, it seems impossible to introduce animals under "scientifically controlled" conditions, because of our lack of knowledge of ecologic conditions. There is an obvious need for more detailed research here. Preferably, introductions should be undertaken only after they are carefully studied and approved by an international board of scientists, for too often exotics have not only become a nuisance in the country to which they were introduced, but also in ad-

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jacent countries where they spread as a "gift."

Overly successful introductions usually lead to a demand for control. This is a complex problem, and it is practically impossible or extremely costly to exterminate introduced species which have become well established.

We have attempted to assemble such data as are available on the introduction of alien species of mammals throughout the world, with a more detailed discussion of the consequences of such introductions in the case of certain conspicuous or economically important species. Our efforts have been more fruitful in certain groups and areas than in others. Orders best represented among introduced mammals are the Lagomorpha, Rodentia, Carnivora and Artiodactyla. Although it appears to be impossible to gather a complete record of all mammals which have been introduced or transplanted during historic time, a fairly good picture has been obtained of what has happened in the more recent past.

The subspecific identity of all forms could not be ascertained but this is presented when known. Space limitations do not permit the inclusion of all known cases of transplantations from one point to another within one continental area, as of deer, elk, rabbits and squirrels in North America.

The scientific and common names follow Ellerman & Morrison-Scott (1951), Miller & Kellogg (1955), Laurie & Hill (1954) and Troughton (1947). Where there is doubt as to the name of the animal in question, that given in the original publication is indicated.

The bibliography, although certainly not exhaustive, is intended as a helpful starting point for investigators interested in geographic areas or groups of mammals. The section on North America was prepared by Manville, that on South America by Van Gelder, and most of the balance by the senior author.

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#### INTENTIONAL INTRODUCTIONS OR TRANSPLANTATIONS

##### *Eurasia:*

Introductions of mammals generally seem to have been less successful in Eurasia than on the other continents. This is the largest land mass and has more species of mammals than the New World. Competition there may be more severe, resulting in less chance of success for exotics. Because most emigrations of the white man have been *from* Eurasia, and because he is mainly responsible for recent animal introductions, the number of alien mammals released *in* Eurasia has been less than in other continents.

No data could be obtained for several countries in southeast Asia, and relatively few for the Soviet Union and China. It seems, however, that in the U.S.S.R. introductions and transplantations of fur-bearers have been accomplished on a large scale. From 1929 to 1948, in more than 500 areas inside the boundaries of the Soviet Union, no less than 21 species of fur-bearers, amounting to about 80,000 individuals, apparently were released (Schmidt, 1954). Another source (Naumoff, 1950) states that from 1925 to 1948 more than 115,000 mammals, of 32 species, were released in the Soviet Union.

Table 1 summarizes the introductions and transplantations in Eurasia.

The introduction of the Muskrat (*Ondatra zibethicus*) into Eurasia resulted in a serious threat to the local economy by damage to dikes and roadbeds and, conversely, in the addition of a valuable fur-bearer to Russia and Finland. Three females and two males from Alaska were introduced in the neighborhood of Prague by Prince Colleredo-Mannsfeld in 1905. More Muskrats, probably from Canada, were liberated later by the same person.

The spread of the species from this first site of release was rapid. In Bavaria, for example, in 1923 and 1924, the rate of emigration is said to have amounted to 30 to 45 miles yearly. In 1914, nine years after the first planting, the population in Bohemia alone was estimated at two million. In 1933, the colonized territory embraced about 64,000 square miles (Mohr, 1933). From Bohemia the Muskrat spread mainly in a northerly and easterly direction and now occupies most of Czechoslovakia, eastern Germany, Poland and parts of Yugoslavia, Romania and European Russia (Text-fig. 1). A good discussion of the early spread of the Muskrat in Europe is presented by Storer (1937).

In the 1920s several subspecies of Muskrat were introduced into fur farms in France. Muskrats escaped from several of these farms, and by 1933 were established in twelve areas. The first capture in the wild was made in 1930. Five



centers of infestation were in the basins of the Seine and the Somme, four were in eastern France and three others were in the center of southeastern France. An active campaign of destruction and the use of a virus resulted in the extermination of Muskrats in southeastern France (Bourdelle, 1939). Muskrats entered Switzerland from the area of infestation in Alsace, and by 1950 about 800 had been killed.

In the Low Countries, the Muskrat occupies nearly all of northern Belgium, as a result of introduction by 1930. In Holland the first Muskrats were caught in 1941, where they are now slowly penetrating along the southern boundary. Government trappers are still keeping the advance in check fairly well (van Koersveld, 1954).

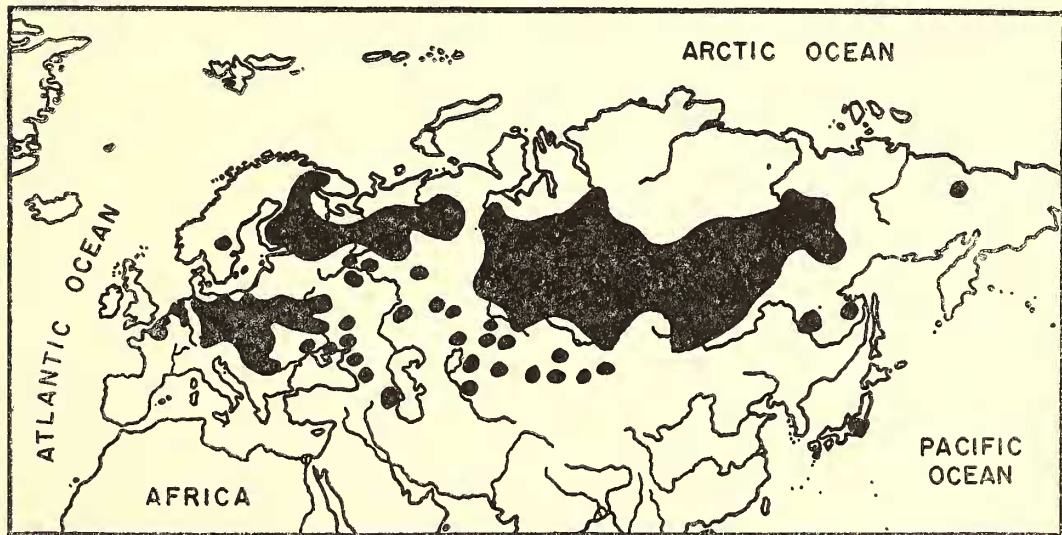
Even before Poland was invaded by the progeny of the Muskrats from Czechoslovakia, some escapees from fur farms had already become established. Nearly all of Poland is now inhabited by the species. The Muskrat was introduced illegally into Sweden sometime before 1944 (Liljeström, 1954). The species was also deliberately introduced at three sites in the lakes region of Finland in 1922 and 1923, from Czechoslovakian stock; other specimens were introduced later from America. They spread from 18 to 25 miles yearly and are now present in most of the country except the extreme north. The Muskrat is now the most important fur-bearer in Finland, in point of value and of numbers, and 150,000 to 250,000 pelts are harvested annually (Schmidt, 1954; Hoffman, 1952).

The Soviet Union first introduced Muskrats in 1927; from then until 1945, 79,198 were re-

leased in the north European and Siberian taiga zone, even as far as Kamchatka, where a shipment arrived from Ontario in 1928 (Eyerdam, 1932). They are still spreading from centers of release (Berger, 1944). In 1941, 150,000 pelts were harvested, and in 1954 about 649,000 (Schmidt, 1954). Nothing specific seems to be known about a supposed introduction into China (Bachrach, 1953). The Muskrat was also introduced in Japan from America, perhaps before 1945; it is confined to Tokyo and environs (Kuroda, 1955).

The only area where the Muskrat has been successfully eradicated is the British Isles. Since 1929 there have existed 87 farms from which animals escaped to establish colonies in England, Scotland and Ireland. Around 1930 it was forbidden to keep Muskrats on fur farms, and a successful system was devised to exterminate them (Warwick, 1934). By 1935, young Muskrats were no longer captured, and by 1939 the campaign was considered terminated; 4,299 animals had been caught.

Only in Finland and Russia is this rodent of value as a fur-bearer, and here no problem of damage seems to exist. In western Europe, however, its burrowing is extremely harmful to dikes, roads and fish-ponds. The freshwater pond-fishing industry accuses it of eating fish and damaging nets; also it raids garden crops. Certainly the sums expended on destruction of Muskrats and repairing their damages are much higher than the profits obtained from fur and flesh. It is still doubtful whether further spread of this introduced mammal can be curtailed.



TEXT-FIG. 1. The present distribution of the Muskrat in Eurasia, derived from stock originally introduced from North America (modified after M. Hoffman, 1952).

TABLE 1: MAMMALS INTRODUCED OR TRANSPLANTED IN EURASIA

Common Name	Scientific Name	Year(s) of Liberation	Country or Place of		Reason for Introduction
			Origin	Introduction	
A: Established; increased in numbers and/or range:					
1. From another continent					
Gray Squirrel	<i>Sciurus carolinensis</i>	1890	N. America	British Isles	Pet
Muskrat	<i>Ondatra zibethicus</i>	1905	Canada?	Czechoslovakia	Fur
Nutria	<i>Myocastor coypus</i>	1930s	S. America	Several countries	Fur farming
American Beaver	<i>Castor canadensis</i>	. . .	N. America	Russia	Fur
American Mink	<i>Mustela vison</i>	Recent	N. America	Scandinavia, Iceland	Fur farming
Alaskan Fox	<i>Vulpes fulva alascensis</i>	Recent	Alaska	Eur. Russia	Fur
American Red Fox	<i>Vulpes fulva</i>	Recent	N. America	Eur. Russia	Fur
White-tailed Deer	<i>Odocoileus virginianus</i>	1934, 1947	U.S.A.	Finland	Hunting
2. From the continent to islands or vice versa, or between islands					
Pig-tailed Macaque	<i>Macaca nemestrina leonina</i>	Recent	Burma	Andaman Is.	?
Formosan Macaque	<i>Macaca cyclopis</i>	Since 1942	Formosa	Oshima, Japan	Escaped
Crab-eating Macaque	<i>Macaca irus</i>	?	Western Indonesia	Celebes, Lesser Sunda Islands	?
Crested Celebes Macaque	<i>Cynopithecus niger</i>	?	Western Indonesia	Batchian Is.	?
Black-naped Hare	<i>Lepus nigricollis</i>	?	India or Ceylon	Java	Hunting
Golden-backed Squirrel	<i>Callosciurus caniceps</i>	1940s	Formosa	Japan	Zool. Gardens
Northern Red-backed Vole	<i>Clethrionomys rutilus</i>	1870	Kamchatka	Bering Is.	?
Fat Dormouse	<i>Glis glis</i>	1886	Europe	British Isles	?
Javan Mongoose	<i>Herpestes javanicus</i>	?	Indonesia	Ambon	?
European Red Fox	<i>Vulpes vulpes</i>	Recent	British Isles	Sweden	Fur
Siberian Weasel	<i>Mustela sibirica coreana</i>	1930s	Korea	Japan	Fur farming
Siberian Weasel	<i>Mustela sibirica itatsi</i>	Before 1901	Japan	Hokkaido	Fur farming, rat control
Ermine	<i>Mustela erminea</i>	1931	Holland	Terschelling Is.	Rat control
Weasel	<i>Mustela nivalis</i>	1931	Holland	Terschelling Is.	Rat control
Masked Palm Civet	<i>Paguma</i> sp?	?	Formosa or China	Japan	Cage animal
Malay Civet	<i>Viverra zangalunga</i>	?	Indonesia	Celebes	?
Common Palm Civet	<i>Paradoxurus hermaphroditus</i>	?	Indonesia	Moluccas	?
Sika Deer	<i>Cervus nippon hortulorum (mantchuricus)</i>	1880s	Manchuria	Europe	. . .
Sika Deer	<i>Cervus nippon nippon</i>	1880s	Japan	Europe	. . .
Sika Deer	<i>Cervus nippon taiouanus</i>	1942	?	Japan	. . .
Fallow Deer	<i>Dama dama</i>	Middle Ages	Asia Minor	Central Europe	Parks
Rusa Deer	<i>Cervus timorensis moluccensis</i>	1855 1913, 1920	Ceram Moluccas	Aru Islands New Guinea	Hunting Hunting
Rusa Deer	<i>Cervus timorensis russa</i>	1680	Java	Borneo	Hunting
Hog Deer	<i>Axis porcinus</i>	18th Century	India	Ceylon, Denmark	Hunting
Mouflon	<i>Ovis musimon</i>	1869	Sardinia or Corsica	Slovakia	Hunting



Common Name	Scientific Name	Year(s) of Liberation	Country or Place of		Reason for Introduction
			Origin	Introduction	
Indian Buffalo	<i>Bubalus bubalis</i>	Recent	India	Andaman Islands	Hunting
3. Transplanted on the continent					
Golden Hamster	<i>Mesocricetus auratus</i>	?	Syria	Germany	?
European Rabbit	<i>Oryctolagus cuniculus</i>	Middle Ages	Europe	Central Europe	?
European Hare	<i>Lepus europaeus</i>	?	C. Europe	Sweden, Far East	Hunting
Raccoon-Dog	<i>Nyctereutes procyonoides</i>	Recent	E. Asia	Soviet Union	Fur
Sable	<i>Martes zibellina</i>	Recent	Trans. to several places		Fur
Stone Marten	<i>Martes foina</i>	Recent	Trans. to several places		Fur
Ferret	<i>Mustela putorius eversmanni</i>	Recent	Trans. to several places		Fur
Sea Otter	<i>Enhydra lutris</i>	Recent	Trans. to several places		Fur
European Mink	<i>Mustela lutreola</i>	Recent	Siberia	Far East	Fur
Arctic Fox	<i>Alopex lagopus</i>	Recent	Siberia	Kola Peninsula	Fur
B: Failed to survive:					
Hog Deer	<i>Axis porcinus</i>	1700s	India	Ceylon	Hunting
		1880	India	Denmark	Hunting
Nubian Ibex	<i>Capra ibex nubiana</i>	1910s	Asia Minor	Czechoslovakia	Hunting
Goat	<i>Capra hircus</i>	1910s	India	Czechoslovakia	Hunting
Chinese Water-Deer	<i>Hydropotes inermis</i>	1850	China	British Isles	Parks
Black-tailed Deer	<i>Odocoileus hemionus columbianus</i>	1850	N. America	British Isles	Parks
Axis Deer	<i>Axis axis</i>	1846	India	Java, Nicobar Is.	Hunting
Indian Muntjac	<i>Muntiacus muntjak</i>	1850	India	British Isles	Parks
Reeves's Muntjac	<i>Muntiacus reevesi</i>	1850	China	British Isles	Parks
C: Transplantations of subspecies to range of other subspecies:					
Roe Deer	<i>Capreolus capreolus pygargus</i>	Before 1914	Siberia	Czechoslovakia	Hunting
Maral Deer	<i>Cervus elaphus asiaticus</i>	19th Century	Siberia	Eur. Russia	Hunting
American Wapiti	<i>Cervus canadensis</i>	19th Century	N. America	Austria	Hunting
Red Squirrel	<i>Sciurus vulgaris exalbidus</i>	Recent	Siberia	C. Russia	Fur
European Beaver	<i>Castor fiber</i>	1927	Norway	Latvia	Fur
		1935	Norway	Letland, Finland	Fur
Red Deer	<i>Cervus elaphus</i>	?	Germany	Norway	Fur
English Red Fox	<i>Vulpes vulpes</i>	Recent	British Isles	Sweden	Fur
Siberian Sable	<i>Martes zibellina</i>	Recent	Several parts of Soviet Union		Fur
D: Status unknown:					
Alpine Marmot	<i>Marmota baibacina</i>	Recent	Soviet Union		Fur
Himalayan Marmot	<i>Marmota bobak</i>	Recent	Soviet Union		Fur
Large-toothed Souslik	<i>Citellus fulvus</i>	Recent	Soviet Union		Fur
Raccoon	<i>Procyon lotor</i>	Recent	N. America	Soviet Union	Fur
Corsac Fox	<i>Vulpes corsac</i>	Recent	?	Soviet Union	Fur
Arctic Fox	<i>Alopex lagopus groenlandicus</i>	Recent	Greenland	Soviet Union	Fur
Russian Desman	<i>Desmana moschata</i>	?	?	?	?
Striped Skunk	<i>Mephitis mephitis</i>	Recent	N. America	Soviet Union	Fur

The American Gray Squirrel (*Sciurus carolinensis*) has become a serious liability since its introduction into the British Isles. Although several early introductions failed, others resulted in restricted local establishments. The present population probably dates from introductions since 1890, although there are several records of the species before that date. Specimens were liberated in southern and central England, in Scotland and in one locality in Ireland. By 1930, Gray Squirrels occupied approximately 13,350 square miles in the greater part of southeastern England, the Midlands and Yorkshire (Middleton, 1930).

Little is known of the present distribution of the Gray Squirrel in Ireland, where it was introduced before 1938. It is, however, extending its range, and is also spreading in Scotland (Shorten, 1953).

The spread of the Gray Squirrel in England is well documented by Shorten (1946, 1953) who devised a system of grids 10 km. square and related the distribution and spread of the squirrel to them. He also tried to correlate the disappearance of the native Red Squirrel (*Sciurus vulgaris leucourus*) with the spread of the Gray Squirrel. While the American intruder was present in 274 grids in 1937, it occurred in 708 in 1944 and 1945, and had spread into an additional 199 by 1952. Apparently in some areas the spread may be halted by such natural barriers as large rivers with few bridges, or by mountainous or treeless country. In no place does the Gray Squirrel inhabit dense coniferous woods, which are the preferred habitats of the Red Squirrel (Middleton, 1930).

After a period of years, the presence of Gray Squirrels may cause the disappearance of Red Squirrels. In 1952, Red Squirrels seemed to have disappeared from areas in eight counties where Gray Squirrels had become established since 1945 (Shorten, 1953). There is little evidence available regarding competition or antagonism between the two species. Possibly the Gray Squirrel carries a disease which is fatal to the Red Squirrel but not to itself. The occurrence of many epidemics after the first appearance of Gray Squirrels supports this contention (Middleton, 1930).

This American immigrant is a serious pest in Great Britain, where only the Norway Rat is considered worse. It does much damage to many kinds of trees, fruits and plants.

The Nutria (*Myocastor coypus*), a native of South America, has been introduced on many fur farms in Europe since 1926. In many cases the animals were released when they were considered a liability, and sometimes they escaped. Wild populations are now present in Russia, Eng-

land, Holland, Denmark, Germany, France and Japan.

In Russia, Nutrias have been imported into Transcaucasia, the Kuban delta, the downstream parts of the Kura and Terek Rivers and the southern part of the Amu-Darja Basin, where they have multiplied. Since 1949, increasing numbers of Nutria pelts have been offered on the market (Schmidt, 1954). Efforts to introduce this fur-bearer into central Russia have failed because of unsuitable climatic conditions. However, the Nutria is successfully established in Armenia, Georgia and the steppes of Shirwan (Lindemann, 1956). Because of low fur prices in 1949, Nutrias were released from several fur farms in Holland. Although the animals are well established, they are readily controlled because of their large size, diurnal habits and trusting ways. According to P. V. Jensen (*in litt.*) several escaped animals are now living in the wild in Denmark, where they are reproducing. In France, Nutrias have escaped from parks in several parts of the country, mostly in the central section. They appear to be maintaining their numbers in the wild state. These rodents were imported from Europe to fur farms in Japan in 1931. A few escaped and established a small breeding population; in 1949 about 500 were known to be present south of Okayama City. Nutrias trample down and eat the rice in the paddy fields (Kuroda, *in litt.*).

Apart from the more spectacular introductions already mentioned, several other rodents have been imported or transplanted. The Red Squirrel (*Sciurus vulgaris exalbidus*) was introduced into central Russia from several parts of Siberia with the result that thousands are now being harvested (Schmidt, 1954).

European Beavers (*Castor fiber*) were reintroduced from Norway into their former range in Sweden in the 1920s. Specimens also were imported from Norway into Latvia in 1927, and again into Latvia as well as Finland in 1935 (Harper, 1945). Beavers also were transplanted to several parts of the Soviet Union, such as the Kola Peninsula, western Siberia and the Volga delta. The American Beaver (*Castor canadensis*) has also been imported into Russia (Naumoff, 1950).

The Syrian Golden Hamster (*Mesocricetus auratus*) has become established locally in the wild in parts of Germany. Here there exists the possibility that it may become a pest in crop lands and food storage places.

The Fat Dormouse (*Glis glis*) was introduced into the British Isles from continental Europe. Rothschild released a few pairs near Tring in 1886, and there were several subsequent importations. After a slow establishment, the spe-



cies gradually spread into several adjoining counties. It seems to be doing little serious damage, and keeps largely to the neighborhood of houses (Cansdale, 1953).

The Formosan Golden-backed Squirrel (*Callosciurus caniceps taiwanensis*) was introduced in zoological gardens on the Island of Oshima, south of Tokyo, some time after 1940. It escaped, and in 1950 an estimated population of 20,000 inhabited many parts of the island. These squirrels chase White-eyes (*Zosterops palpebrosa*) from the flowers of the camellia, resulting in lack of fertilization of this plant. Other trees and shrubs are stripped of their bark, and nuts also are eaten. These activities result in a considerable decrease in the production of camellia oil, the island's principal commodity.

The northern Red-backed Vole (*Clethrionomys rutilus*) was introduced in 1870 from Kamchatka to Bering Island, one of the Commander group. Within ten years it spread over all the island from the beaches to the interior mountains. It occurs both in the swamps and on the sand dunes, and has become a pest in the huts of the natives (Palmer, 1899).

*Marmota baibacina*, *Marmota bobak* and *Citellus fulvus* have also been transplanted within the Soviet Union (Naumoff, 1950).

The European Rabbit (*Oryctolagus c. cuniculus*) undoubtedly has a much wider distribution in central and western Europe now than in Roman times, and it still seems to be extending its range, assisted by man. It was introduced in the Middle Ages into Germany and Holland for hunting purposes and reached the British Isles from central Europe in the Twelfth Century (Cansdale, 1953). In Denmark it has been released in several places in the past fifty years, but has not increased greatly. About 1920 it crossed the Danish border from an isolated German population released about 1900 (Jensen, *in litt.*). The rabbit has also been released in the Soviet Union (Naumoff, 1950) and in China (Allen, 1938). Rabbits were liberated on one of the islands of the Madeira group in the Fifteenth Century; they increased so rapidly as to seriously deplete the vegetation.

Although rabbits are popular game animals and provide much meat and many skins, they are nevertheless destructive pests in that they raid gardens, kill many tree seedlings and reduce the carrying capacity of pastures for livestock. They also compete seriously for food with the European Hare. The recent myxomatosis outbreak in western Europe has changed the picture completely; rabbits have become very scarce.

Other introduced lagomorphs include the European Hare (*Lepus e. europaeus*) in the Far

East (Lindemann, 1956) and also in Sweden, where it is gradually replacing the Alpine Hare (*Lepus timidus*), possibly because of a higher reproductive potential. A pair of Alpine Hares was introduced from Norway to the Faroe Islands in 1854-55; their descendants have given rise to a new subspecies, *seclusus*. Immediately following their introduction, all the hares turned white in winter, but today they retain their dark coats throughout the year (Bourlière, 1954). This species has also been transplanted from the Scottish Highlands to the southern uplands and to the island areas of the Highlands (Darling, 1947). The Black-naped Hare (*Lepus nigricollis*), a native of India and Ceylon, has been introduced around Djakarta, Indonesia, and now occurs also near Bogor and Bandoeng (van Bemmel, *in litt.*).

The few transplantations of monkeys in Asia include the Celebes Crested Macaque (*Cynopithecus niger*) to the island of Ambon and the Crab-eating Macaque (*Macaca irus*) to Celebes and the Lesser Sunda Islands from the more westerly islands in the Indonesian Archipelago. The Formosan Rhesus Monkey (*Macaca cyclopis*) escaped from captivity on Oshima Island, south of Tokyo, and multiplied rapidly in the absence of natural enemies; there is some doubt as to whether it occurs in the wild at Kivozumi (Prefecture Chiba), Hondo. The Pig-tailed Macaque (*Macaca nemestrina leonina*) was introduced from India to the Andaman Islands (S. L. Hora, *in litt.*).

The Javan Mongoose (*Herpestes javanicus*) has been introduced to Ambon from other islands in the Indonesian Archipelago. One Palm Civet (*Paradoxurus hermaphroditus*) was introduced throughout the Moluccas and the Lesser Sunda Islands, and the Malav Civet (*Viverra zangalunga*) was imported into Celebes. The Masked Palm Civet (*Paguma* sp.) was imported into Japan in ancient times and again more recently as a cage animal; it probably came from Formosa (*P. taivana*) or from South China (*P. larvata*). Some evidently escaped, according to sporadic records from Central Hondo and Shikoku. The animal is said to have been caught in the Prefecture of Yamanashi in early times, and again more recently.

The Mouflon (*Ovis musimon*), although reduced in numbers in its native Sardinia and Corsica, appears to have thrived in various continental areas. It has become established in Germany, Czechoslovakia, Austria, Rumania, European Russia, Holland and Denmark. In 1869, ten were transferred to the Tribec Mountains of Slovakia, where they became established. Several herds are now dispersed over Germany and



Austria. The herd in Holland, numbering about one hundred head, was started in 1918-19. In 1951-52 Mouflons were released on private lands in Southfyn, Denmark (Jensen, *in litt.*). The species was introduced into Italy during the mid-1800s, but has long since disappeared (Harper, 1945). According to Turcek (*in litt.*) Mouflons were introduced to the Crimea and South Ukraine before World War I. It is of interest that a new race developed in the Slovakia range; about 1910 a distinctly different type of sheep was common, in which the rams are darker in color, lack the saddle patch and possess short, thick horns with converging tips (Allen, 1954).

In 1910 two goats, the Bezoar Goat (*Capra hircus*) and the Nubian Ibex (*Capra ibex nubiana*) were introduced from Asia Minor into the High Tatra Mountains of Czechoslovakia. They interbred with the native Ibex (*Capra i. ibex*), reintroduced since 1901. The hybrids did not do well, possibly because they were born during the dead of winter rather than in spring, as are the native Ibex (Turcek, 1951).

The Indian Buffalo (*Bubalus bubalis*) has been recently introduced into the Andaman Islands from India. The availability of considerable food and the absence of predators have aided its establishment, and it is slowly extending its range (Hora, *in litt.*).

In 1929, seventeen Muskoxen (*Ovibos moschatus*) were introduced from East Greenland to Spitzbergen. This herd appeared to be thriving in 1950 (Anon., 1952a).

Several species of deer have been introduced or transplanted in Eurasia. The Fallow Deer (*Dama d. dama*), originally from Asia Minor, has been widely imported in captivity, and also liberated in the wild. In Denmark it was mentioned in the literature as early as 1231, having been introduced by the Danish Kings for hunting; it now occurs in deer parks as well as in the wild, and its numbers were estimated at 3,300 head in 1950 (Jensen, *in litt.*). Fallow Deer have been in Germany since the Middle Ages, but their population is small. They were introduced into the Bialowies Forest of western Russia about 1890, but required special care; none have been observed since 1930 (Lindemann, 1956).

Sika Deer have been introduced at several places in western Europe as well as in eastern Asia. Two subspecies reached the British Isles, *Cervus n. nippon* from Japan and *C. n. manchuricus* (= *hortulorum*) from Manchuria, near Loch Rosque from 1880 to 1890. Their range still centers about the Achnasheen area. Another introduction in 1893 still survives at Carradale, Kintyre (Darling, 1947). Sika Deer are numer-

ous in parts of the Midlands and in the southern counties from Kent to Dorset (Matthews, 1952). H. G. Lumsden (*in litt.*) reports them present near Inniskillen, Ireland. The Japanese race first reached Denmark around 1900, and was later liberated from captivity; about 500 of these animals are now living in the wild (Jensen, *in litt.*). Sika Deer are still reported in the wild in France. In Japan, *Cervus nippon taiouanus* was released on Oshima Island, south of Tokyo, about 1942-43; fifty were observed here in 1950 (Kuroda, 1955). The Manchurian Sika (*C. n. hortulorum*) has been released in the Soviet Union (Naumoff, 1950).

The Hog Deer (*Axis porcinus*) was introduced to the western parts of Ceylon during the Dutch occupation in the Eighteenth Century. Here it multiplied and persisted until about 1920, but since then, with increased human population and heavier hunting pressure, it has been practically extirpated (C. W. Nicholas, *in litt.*). This species, from India, was liberated on Samsö Island, Denmark, in 1880, but no longer exists there (Jensen, *in litt.*).

The Axis Deer (*Axis axis*), introduced from India to the Nicobar Islands in 1846, seems to have disappeared there, for reasons unknown (Hora, *in litt.*).

Reeves's Muntjac (*Muntiacus reevesi*) and the Indian Muntjac (*Muntiacus muntjak*), as well as the Chinese Water Deer (*Hydropotes inermis*) and the Black-tailed Deer (*Odocoileus hemionus columbianus*), have apparently escaped or been released from parks in the British Isles since 1850 (Matthews, 1952). They seem to survive in the wild in small numbers. Barking Deer have been reported introduced from Bali to Lombok (Everett, *in litt.*). Sambar Deer (*Cervus unicorn*) have been transplanted from the Philippine Islands to Guam and Rota (Baker, 1946).

White-tailed Deer (*Odocoileus virginianus*) from Minnesota have twice been released in Finland. One buck and four does, liberated 100 miles north of Helsinki in 1934, had multiplied to more than 200 by 1947. A further introduction of three bucks and three does was made in 1948 (Connelly, 1948). The next year some damage to forests and isolated farms was noted (Salmi, 1949).

Deer have been widely transported throughout the eastern part of the Indonesian Archipelago; in some instances the circumstances are known. Rusa Deer (*Cervus timorensis russa*) were introduced into Ambon from Java and later from Celebes (where they were not native) during the Seventeenth Century. In the Aru Islands, deer (*Cervus timorensis moluccensis*) were imported from Ceram in 1855, and are now numbered in the thousands. In South Borneo Rusa Deer were

introduced near Mataram about 1680; these increased to enormous herds in the Nineteenth Century, but have since declined (van Bemmelen, 1952). In Netherlands New Guinea, *C. t. moluccensis* now occurs on the Onin Peninsula (introduced from Ceram in 1913) as well as on the eastern coast of the "Birdshead" (around Manokwari) and near Hollandia, the latter stock from Halmaheira in 1920 (Westermann, 1947).

Three species of deer have been transplanted in Europe with poor results. The Siberian race of the Roe Deer (*Capreolus capreolus pygargus*), released in Czechoslovakia prior to World War I, hybridized in some localities with the smaller native race; crosses involving a native female produced a fetus too large for parturition. Effects of crosses with native males are still perceptible in bucks with abnormally high and thick antlers (Turcek, 1951). In the British Isles, Siberian Roebuck have escaped from parks since 1850 (Matthews, 1952); they have also been transplanted within the Soviet Union (Naumoff, 1950).

The transplantation of German Red Deer (*Cervus elaphus*) into Norway has apparently resulted in the virtual extermination of the species there, probably because the German strain was less hardy. A few hundred American Elk (*Cervus canadensis*) were introduced to Austria by Francis Joseph I (Lorenz, 1953). Asiatic elk have also been transplanted in Russia (Naumoff, 1950).

Central Maral Deer (*Cervus elaphus asiaticus*) from Asia and American elk (*Cervus canadensis*) were introduced into European Russia in the days of the Czars. Hybridization between the two species resulted in the development of animals with antlers having less spread, fewer points and poorly developed burrs (Lindemann, 1956).

Other ungulates transplanted within the Russian orbit include the European Bison (*Bison bonasus*), the Siberian Ibex (*Capra ibex sibirica*) and the Wild Boar (*Sus scrofa*) (Naumoff, 1950).

Many carnivorous fur-bearers have recently been transplanted in the wild, especially in the Soviet Union. The Raccoon-dog (*Nyctereutes procyonoides*) from extreme eastern Asia was introduced into the Baltic Republics and into White and Middle Russia from Smolensk to the Urals. In central Russia this animal is now one of the principal fur producers, but in Siberia its fur proved to be less valuable and the animals soon competed seriously with the more highly regarded native mustelids (Lindemann, 1956). It is reported that in the Caucasus the Raccoon-dog changed its food habits from fish and crabs to game birds, hares and poultry.

Several forms of Mink have been transplanted for their furs. *Mustela vison* from North Amer-

ica has escaped from fur farms in Norway, Sweden, Denmark, the Soviet Union and Iceland. Their status in Norway is described by Wildhagen (1956). In the Scandinavian countries they are a serious problem because of their depredations; whether they are yet fully established in Denmark is not certain (Jensen, *in litt.*). The Iceland escape is rather recent, but damage to native wildlife already has been reported (Anon., 1953b).

The Siberian Weasel (*Mustela sibirica coreana*) was imported from South Korea to Japan after 1930, where it escaped from fur farms and bred with the native *M. s. itatsi* which it is gradually replacing; it has already extended into southwestern Hondo and the eastern parts of Shikoku. The Japanese race, introduced into Hokkaido before 1901, has increased and spread; it was further transplanted to two small islands off Hokkaido in 1933, and in 1948 was imported into Okujirijima in the hope of exterminating *Rattus norvegicus* and *Apodemus*.

Lindemann (1956) refers to the introduction of the European Mink (*Mustela lutreola*) into the Far East.

An interesting case of differential survival is recounted by van Koersveld (*in litt.*). In 1931 nine Ermines (*Mustela erminea*) and 102 weasels (*Mustela n. nivalis*) were introduced on the island of Terschelling, Holland, to diminish an abundance of rabbits and rats. By 1953, the Ermines had increased to a high population, but the weasels had entirely disappeared. A bounty is now set on the Ermines, which kill many wild birds and poultry.

Sables have been transplanted from the Trans-Baikal to several parts of the Ural and Altai Mountains. The Kamchatka Sable (*Martes zibellina kamtschadalis*) was introduced into western Siberia, where it has interbred with the native form. The resultant hybrids have heavier and more valuable furs than the native animal (Lindemann, 1956).

Other mustelids introduced or transplanted in the Soviet Union include the Stone Marten (*Martes foina*), the Skunk (probably *Mephitis mephitis*), the Siberian Weasel (*Mustela sibirica*), the Sea Otter (*Enhydra lutris*) and the Ferret (*Mustela putorius eversmanni*) (Naumoff, 1950).

The North Siberian Polar Fox (*Alopex lagopus*) has been released on the Kola Peninsula (Lindemann, 1956). The introduction of Red Foxes (*Vulpes vulpes*) from England to Sweden may be responsible for the appearance of numerous "Samson foxes"—individuals lacking guard hairs and therefore of little value for their fur. Alaskan Silver Foxes (*Vulpes fulva alascensis*) were released in Finland in 1938 with the idea of producing a good cross-fox hybrid between it



and the native Red Fox, and interbreeding seems to be occurring. In European Russia large numbers of North American Silver Foxes were released (Schmidt, 1954). Naumoff (1950) lists also *Vulpes fulva*, *Vulpes corsac* and *Alopex lagopus groenlandicus* as introductions in the Soviet sphere.

The Raccoon (*Procyon lotor*) is the only other carnivorous fur-bearer introduced into the Soviet area which is mentioned by Naumoff (1950). It is present in the Far East (Ussouri) and in European Russia.

#### North America:

North America, and the United States in particular, seems to have received an unduly large number of introductions. Why this continent, with a rich and varied native mammalian fauna, should have been subjected to the importation of numerous exotics is not clear, but a possible explanation is the dependence of the colonists upon hunting and trapping for food and clothing. The spread of settlements from Atlantic to Pacific led to the virtual annihilation of some important and valuable animals, such as the Beaver, the Bison and other ungulates. The depletion of several major game species did not necessarily result in the loss of hunting as a privilege, but led to the use of other, perhaps less desirable, species as game. North Americans have come to consider hunting and trapping as a portion of their heritage, and many of the introductions and transplantations of mammals may be related directly to attempts to provide added materials to bolster the reduced numbers of native mammals.

In no case have foreign implants been an unqualified success; generally they have been failures. Several colonies of exotic monkeys, of various species, are established in the Caribbean region (Miller & Kellogg, 1955). The last few years have seen the successful introduction of the Barbary Sheep (*Ammotragus lervia*) into New Mexico (O'Conner, 1953), the release of the European Rabbit (*Oryctolagus cuniculus*) in Pennsylvania and the liberation of the Chinchilla (*Chinchilla* sp.) in California (Voris *et al.*, 1955).

Accidental introductions or escapes take place from time to time, but seldom are these followed by the permanent establishment of the species. Examples of failures are the Blue Fox (*Alopex lagopus*) in Minnesota (Bailey, 1929) and the Coatiundi (*Nasua narica*) in Oklahoma (Glass & Hanson, 1952) and in Indiana (Lyon, 1923).

Worthy of special studies in themselves are the details of the many transplantations, from state to state, of Pronghorns (*Antilocapra americana*) (Fisher, 1942; Nichol, 1942), American

Elk (*Cervus canadensis*) (Atwood, 1938; Kirk, 1923; Scheffer, 1941), Muskrat (*Ondatra zibethicus*) (Dickey, 1923; Eyerdam, 1932; Storer, 1937) and other favored game and fur-bearing mammals (Dice, 1927; Dixon, 1929; Bailey, 1936). These species have been transplanted widely and, as a result, several local races, particularly of the Elk and Muskrat, have been mixed.

Countless experimental plantings have been tried and a few examples may be cited. On Anticosti Island, in the Gulf of St. Lawrence, have been made introductions of Moose (*Alces alces*), American Elk, Whitetail Deer (*Odocoileus virginianus*), Bison (*Bison bison*), Mink (*Mustela vison*), Fisher (*Martes pennanti*), Red Fox (*Vulpes fulva*), Beaver (*Castor canadensis*), Muskrat and Varying Hare (*Lepus americanus*) (Newsom, 1937). On Lanz Island, British Columbia, Mink were imported from Vancouver Island about 1938; by 1950 they were so plentiful as to force out the pelagic birds which formerly nested there. From here, these Mink populated Cox Island, on which Raccoons (*Procyon lotor*) from Vancouver had also been planted in 1938. The Raccoons became established, but had not by 1950 become as injurious as the Mink (Clifford *et al.*, 1951).

Massachusetts has introduced, on the islands of Nantucket and Martha's Vinyard, Varying Hares, Black-tailed Jackrabbits (*Lepus californicus*), European Hares (*Lepus europaeus*), Florida Cottontails (*Sylvilagus floridanus*), Red Fox, Prairie Dogs (*Cynomys ludovicianus*) and Fallow Deer (*Dama dama*). The foxes and Prairie Dogs became such pests that they were exterminated; the Fallow Deer seemingly compete for food with the White-tailed Deer on Martha's Vinyard; the Florida Cottontail probably competes with the native *Sylvilagus transitionalis*. It is believed that western rabbits introduced tularemia to these islands (Starrett, *in litt.*).

In New York State, since 1886, released game and fur-bearing mammals have included Raccoon, Red Fox, Coyote (*Canis latrans*), Timber Wolf (*Canis lupus*) Beaver, Muskrat, Fox Squirrel (*Sciurus niger*), Varying Hare, Cottontail, European Hare, Pronghorn, Black-tailed Deer (*Odocoileus hemionus*), White-tailed Deer, Moose, Elk, Red Deer (*Cervus elaphus*), Japanese and Siberian Deer and Wild Boar (*Sus scrofa*). Only the Beaver and White-tailed Deer plantings were successful (Bump, 1940). The State of Washington has witnessed the establishment of the Virginia Opossum (*Didelphis marsupialis*), eastern Fox Squirrel, Gray Squirrel (*Sciurus carolinensis*), eastern Cottontail, Nutria (*Myocastor coypus*) and the Pronghorn (Buechner, 1953; Dalquest, 1948). In Michigan, Jack-



rabbits (*Lepus townsendii*), European Hares, Nutria, Reindeer, Moose and Elk have been introduced (Blouch, 1954; Ruhl, 1940). Alaska has seen the introduction of ground squirrels (*Citellus undulatus*), Raccoons, Blue Foxes, Black-tailed Deer, Reindeer, Roosevelt Elk, Bison and Muskoxen (Murie, 1940; Scheffer, 1947; Palmer, 1954). Muskrats and ground squirrels failed to survive on the Pribilof Islands (Preble, 1923).

In Texas, several ranchers have experimented with exotic game species. At least some of this stock is on open range and hence might possibly become established in the wild. The King Ranch has introduced White-tailed Deer, Elk, Japanese Fallow Deer, Indian Blackbuck (*Antelope cervicapra*) and Nilgai Antelope (*Boselaphus tragocamelus*); only the last two survived (Lehmann, 1948). The Bar-O Ranch has stocked the Sardinian Mouflon (*Ovis musimon*) which later crossed with domestic sheep, the Blackbuck, Asiatic Serow (*Capricornis sumatraensis*), and Aoudads. The Rickenbacker ranch has kept European Fallow Deer, Roe Deer (*Capreolus capreolus*), Asiatic Sambar (*Cervus unicolor*) and Blackbuck on a large scale (O'Conner, 1953). Some zoological gardens in Texas are selling Axis Deer and antelopes for the stocking of ranches. It is estimated that at least 1,000 wild Blackbuck exist in Texas alone today, and they are on the increase (Stilwell, 1955). Similar instances of large scale introductions or transplantations might be related for California (Storer, 1931, 1933), North Carolina (Anon., 1953a), Ohio (Hicks, 1940), Ontario (Soper, 1923), Pennsylvania (Anon., 1944), Saskatchewan (Forsyth, 1942), Utah (Popov & Low, 1953) and elsewhere.

Kangaroo Rats (*Dipodomys ordii*) have been introduced on the sand dunes on the shores of Lake Erie, near Fairport, Ohio, and are established (Bole & Moulthrop, 1942).

Happily, the short-sighted policy of wholesale introduction on a hit or miss basis is no longer as common as it once was. Missouri has recently stopped its long practice of supplying Cottontails to many other states in the northeastern United States. Still, there are reports of plantings of Great Plains Jackrabbits (*Lepus californicus*) in Kentucky (Myers, 1952) and of European Rabbits from the San Juan Islands off the coast of Washington to Pennsylvania and elsewhere (Anon., 1954b).

Table 2 summarizes the status of introduced mammals in North America. The following introductions or transplants are discussed in detail.

The Nutria (*Myocastor coypus*) has been imported for its fur in many places in the United States and Canada. Escapees or releases from

fur farms have survived in the wild and several local populations have increased. The animal seems best established in the marshes of the southeastern states (Dozier, 1951) and of Oregon, where it is the subject of much debate. Its pelt commands a low price and is in little demand. In Louisiana it is increasing rapidly and competing seriously for food with the more valuable muskrats, which are reported on the decline (Ashbrook, 1953). It was reported on the Pacific coast by 1942 (Larrison, 1943) and is now in Washington (Dalquest, 1948). In California most of the escaped Nutrias were killed (Storer, *in litt.*). Colonies are reported living in a feral state in Montana (Jellison, 1945), Texas (Petrides, 1950; Swank & Petrides, 1954), Ohio, Kansas and Michigan.

The Muskrat was transplanted to Vancouver Island, to other islands off the coast of British Columbia, and to several localities in California (Storer, 1937). The population has spread since the original releases were made.

From 1888 to 1911 European Hares were liberated at various places, and some of these releases survived (Osborn, 1933). The earliest well-authenticated releases were in Brant County, Ontario, in 1912 (Dymond, 1922). From here they spread rapidly, and by 1923 were reported in several localities in Wellington and Waterloo Counties (Soper, 1923). They were further introduced near Thunder Bay, Ontario (Allin, 1950). They are now reported in all of southern Ontario (Reynolds, 1952). These hares, although good game animals, are often pests, consuming crops and damaging orchards. By 1950, they were considered to be established beyond hope of eradication in southern Ontario and in Michigan (Cahalane, 1950). In addition, they have also invaded northern Wisconsin and Minnesota, and range from the St. Lawrence across northeastern New York (Hamilton, 1952) and extreme western New England into New Jersey and eastern Pennsylvania.

The introduction of the European Rabbit on the mainland of North America is recent and may still be susceptible of control. On other continents this burrowing rabbit seriously competes for forage even with sheep, undermines buildings, kills vegetation and causes erosion. A population has existed on the San Juan Islands, off the coast of Washington, perhaps since the days of the Hudson's Bay Company occupation (Thompson, 1955). In 1900 and thereafter more "Belgian Hares" or "tame rabbits," a domestic form raised for fur and meat, were released by the lighthouse keeper on Smith Island to supplement the earlier population. Introductions followed on several other islands of the San Juan group. Numbers increased and reached plague

TABLE 2: MAMMALS INTRODUCED OR TRANSPLANTED IN NORTH AMERICA

Common Name	Scientific Name	Year(s) of Liberation	Country or Place of		Reason for Introduction
			Origin	Introduction	
A: Established; increased in numbers and/or range:					
Raccoon	<i>Procyon lotor</i>	1932	Florida	Bahamas	Curiosity
Mink	<i>Mustela vison</i>	1938	Vancouver	Scott Islands, B.C.	Fur
European Red Fox	<i>Vulpes vulpes</i>	18th Century	W. Europe	N.E. U.S.A.	Hunting
Nutria	<i>Myocastor coypus</i>	1940?	S. America	Louisiana	Fur
European Hare	<i>Lepus europaeus</i>	1912	Europe	Ontario	Sport, food, fur
European Rabbit	<i>Oryctolagus cuniculus</i>	1900	Europe	Washington	Fur, food
		1953		Pennsylvania	Hunting
Wild Boar	<i>Sus scrofa</i>	1912	Germany	N. Carolina	Sport
Fallow Deer	<i>Dama dama</i>	1938	?	Nebraska	Sport
Peccary	<i>Pecari angulatus</i>	?	Yucatan	Cozumel Island, Mexico	Food?
Kangaroo Rat	<i>Dipodomys ordii</i>	?	S.W. U.S.A.	Ohio	Curiosity
Jaguarundi	<i>Felis yagouaroundi</i>	Before 1942	Central or S. America	Florida	?
B: Survived but did not spread:					
Three-toed Sloth	<i>Bradypus griseus</i>	1925	Panama	Barro Colorado Island	Curiosity
Sambar Deer	<i>Cervus unicolor</i>	1900	Asia	Florida	Sport
Fallow Deer	<i>Dama dama</i>	?	Europe	Texas	Sport
Roe Deer	<i>Capreolus capreolus</i>	?	?	Texas	Sport
Blackbuck	<i>Antilope cervicapra</i>	?	India	Texas	Sport
Nilghai	<i>Boselaphus tragocamelus</i>	?	India	Texas	Sport
Mouflon	<i>Ovis musimon</i>	?	Sardinia	Texas	Sport
Serow	<i>Capricornis sumatrensis</i>	?	Asia	Texas	Sport
Aoudad	<i>Ammotragus lervia</i>	1950	Africa	New Mexico	Sport
Axis Deer	<i>Axis axis</i>	1930s	India	Florida	Escapees
C: Failed to survive:					
Coatimundi	<i>Nasua narica</i>	1950	?	Oklahoma	Escaped
Blue Fox	<i>Alopex lagopus</i>	1927	Arctic	Minnesota	Escaped
Ground Squirrel	<i>Citellus undulatus</i>	1899	Alaska	Pribilof Is.	Food for foxes
Muskrat	<i>Ondatra zibethicus</i>	1913	Nushagak	Pribilof Is.	Fur
Red Deer	<i>Cervus elaphus</i>	?	?	?	Sport
Sika Deer	<i>Cervus nippon</i>	?	Japan	?	Sport
German Deer	<i>Cervus elaphus</i>	?	Germany	?	Sport
Fallow Deer	<i>Dama dama</i>	?	Japan	Texas	Sport
Roe Deer	<i>Capreolus capreolus</i>	?	Siberia	?	Sport
D: Successful transplantations (only a partial list, covering little-known cases):					
Marten	<i>Martes americana</i>	1953	Ontario	New Hampshire	Aesthetic
		1954	Montana	Wisconsin	Aesthetic
Muskox	<i>Ovibos moschatus</i>	1930	Greenland	Alaska	Food, clothing
Armadillo	<i>Dasypus novemcinctus</i>	1918	Mexico	Florida	Curiosity
Mountain Goat	<i>Oreamnos americanus</i>	1948	Rocky Mts.	S. Dak., Colo.	Hunting



proportions by 1924, when the rabbits were estimated at over thirty to the acre on Smith Island. Wholesale poisoning was undertaken, and nearly 2,000 were probably killed (Couch, 1929). But the rabbits have persisted, and of late are being introduced elsewhere. Feral stocks also occur on South Farallon Island, 30 miles west of San Francisco (Storer, *in litt.*). Shipments have recently reached Ohio, Pennsylvania, Indiana and Wisconsin (Barnes, 1955). The implicit dangers have been publicized (Anon., 1954b; Thompson, 1955). Perhaps, as was the case in Australia and New Zealand, these initial releases may prove unsuccessful, and this new exotic may not further extend its range into North America.

The Nine-banded Armadillo (*Dasypus novemcinctus*), which gradually has been extending its range northward into Texas since the 1880s, was probably introduced into Florida during World War I (Bailey, 1924). It thrived, and by 1952 occurred over all the state except the swampy southwestern portion and possibly the western panhandle (Neill, 1952). It is regarded as highly undesirable because its burrowing activities undermine buildings, damage gardens and penetrate dikes and levees; on the other side of the picture, the armadillo's burrows provide homes for other animals, its meat is edible, and its horny armor is made into novelties for the tourist trade. It now also occurs in Arkansas, Louisiana, New Mexico and Oklahoma, and has been reported from Alabama, Georgia, Kansas and Missouri (Fitch *et al.*, 1952). In part, this spread appears to be by natural means; its course has been well summarized by Buchanan (1955).

Introduction of Wild Boars (*Sus scrofa*) from the Harz Mountains of northern Germany, primarily for sport, began in 1912 with the arrival of fifteen males and fifteen females. They were kept in a 600-acre enclosure near Hooper Bald, North Carolina, until 1920, when about 100 escaped and persisted in the wild (Stegeman, 1938). They were decimated by hog cholera in 1932, but by 1937 it was estimated that there were about 230 in the region. Some of these were released near Carmel, California, in 1924 and persisted at least until 1938 (Shaw, 1940). Wild Boars readily breed with domestic swine. They are regarded by some as desirable game animals, but also they are harmful to vegetation and to ground-dwelling animals. Their greatest population is currently in the mountain forests of eastern Tennessee, but they exist also in Georgia, North Carolina, Oregon, Texas and on the Corbin Preserve in New Hampshire (Baynes, 1923; Cahalane, 1950; Scheffer, 1941).

The introduction of the Moose into Newfoundland (Pimlott, 1953) may be cited as an

instance of the establishment of a mammal which greatly augmented the big game resources of the province and which apparently filled a niche at least partly vacant. Two introductions were made, in 1878 and in 1904. The second attempt resulted in complete establishment. In twenty years the radius of distribution had extended to at least 80 miles from the point of release. At present the species is well established on the entire island, with a bull kill of approximately 14,000 over a period of eight years. Moose have also been introduced into Labrador.

As recently as about 1938, some sixty white Fallow Deer (*Dama dama*), original source unknown, were released on the Hall Ranch ten miles northwest of Petersburg, Boone County, Nebraska. They have reproduced and spread, being reported in 1955 from five counties in central Nebraska (Packard, 1955), where they do some damage to orchards and to crops.

Sambar Deer (*Cervus unicolor*) from a zoological park were released on St. Vincent's Island, near Appalachicola, Florida, in 1900. They have since reproduced and thrived.

The Greenland Muskox (*Ovibos moschatus*), indigenous to the northern mainland and to many parts of the Arctic islands, has been introduced on Nunivak Island, Alaska, where it competes directly with the introduced Reindeer.

Aoudads or Barbary Sheep (*Ammotragus lervia*) have recently been introduced into New Mexico (O'Connor, 1953) and have been promoted for release as game animals in Texas. A large herd is established in the wild on the St. Simeon Ranch near San Luis Obispo, California (Lindemann, *in verbis*).

Dwindling herds of Bighorn Sheep (*Ovis canadensis*) in our western mountains have been supplemented by stock from British Columbia. Twenty individuals were released in the Hart Mountains of eastern Oregon in 1954, and others in several localities in Colorado, Montana and New Mexico (Buechner, 1956).

There is some evidence that the present Red Fox of the eastern United States is a direct descendant of the European Red Fox (*Vulpes vulpes*) which was introduced between 1650 and 1750 from England for fox hunting (Gilmore, 1946).

On Barro Colorado Island, in the Panama Canal Zone, six Three-toed Sloths (*Bradypus griseus*) from nearby Frijoles were released in 1925 (Enders, 1930). Their present status is not known.

In 1942, Jaguarundis (*Felis yagouaroundi*) were reported in Florida. These animals are believed to have been released deliberately at Chiefland and Hillsborough River State Park. Repeated observations of animals believed to be Jaguar-



undis suggest that they are present in the following areas: Dunellon through Chiefland to Jena, eastern Marion County; the south end of the central Florida ridge in Osceola, Polk and Highlands Counties; Everglades National Park; and possibly Hillsborough County. Specimens identified as *Jaguarundis* have been obtained from Jena and near Lake Placid. The animals seem to prefer areas of thick brush near water. Most of the sight-records were made while they were raiding chicken coops and poultry yards (Neill, *in litt.*).

Axis Deer (*Axis axis*) escaped in Volusia County, Florida, in the 1930s, and they are now known from four counties east of the St. John's River. Since 1951, they have been protected by state law (Allen & Neill, 1954).

The Mountain Goat (*Oreamnos americanus*) was transplanted from its original range in the Rocky Mountain area to the Black Hills in South Dakota, where the species is thriving. It was also introduced into Colorado, at least three of the eleven animals released in 1948 still surviving in 1954 (Yeager, *in litt.*), and into several areas in central Montana (Cahalane, *in litt.*).

Pine Martens (*Martes americana*) have been transplanted during recent years to states where they had been exterminated. Reintroduction from Ontario into New Hampshire appears to be successful (Monahan, 1953). Martens also were transplanted from Montana to Wisconsin.

Bison have been introduced (reintroduced?) and established in northern Sonora, Mexico. Whitetail Deer, reintroduced in the mountains of central Mexico, have failed to survive because of heavy hunting pressure to which they are subjected (Villa-R., *in verbis*). Elk have also been introduced or reintroduced in Wauwala.

Peccaries (*Pecari anoulatus*) on Cozumel Island, Quintana Roo, Mexico, have been described as a subspecies (*nana*), but it is believed that these animals were introduced from the mainland and that the subspecific characters (small size) are the result of heavy hunting pressure which allows few animals to attain more than two years of age (Herskovitz, 1953).

#### South America:

South America, with a continental area larger only than Australia, has been isolated for long periods of geological history. This separation from the other continents, together with major barriers within South America such as the western Cordillera, the tropical forests of the Amazon basin, and the Pampas, has resulted in differentiation of a unique mammalian fauna. Because many native mammals, especially carnivores and ungulates, although specialized,

seem to be more primitive than other allied forms living elsewhere, the South American fauna may be highly susceptible to deleterious effects by more highly developed competitors from other continents as well as by intracontinental introductions.

Table 3 summarizes the status of introduced and transplanted mammals in South America.

The European Rabbit (*Oryctolagus cuniculus*) was introduced on islands in the Beagle Channel, Tierra del Fuego, about 1880, by Thomas Bridges, a missionary. These rabbits, brought from the Falkland Islands, were introduced to provide food both for castaways and for the natives, and care was taken to avoid introduction on the mainland. On some islands the rabbits reproduced rapidly, while on others they failed to survive because of predation by birds, hunting pressure by the Indians (who used dogs), or because the land was too rocky or wet for burrowing (Bridges, 1949). Eventually the rabbits reached the mainland and have spread northward, west of the Cordillera, at least as far as Vallenar, Chile. They caused considerable damage to the flora, destroying young pines (*Pinus insignis*) and the native grass cover (Mann, *in litt.*). The European Rabbit is also reported established in Argentina (Sanborn, *in litt.*).

The European Hare (*Lepus europaeus*) was introduced into Argentina in 1880, and has spread to Chile during the present century. It causes much damage to pastures and is found in large numbers in central and southern Chile, north at least to Illapel, and at elevations as high as 2,600 meters (L. E. Peña, *in litt.*). The pelts of the European Hare and European Rabbit are used in various industries, and 50,000 skins were sold in Punta Arenas in 1939. According to C. C. Sanborn (*in litt.*) this hare was introduced into Uruguay and also Tierra del Fuego. He reported range damage by these animals in Patagonia.

The Mongoose (*Herpestes auropunctatus*) was introduced into British Guiana on the mainland of South America from Caribbean stock after 1872. It has multiplied and spread to settled areas, but does not seem to have penetrated farther. The dense tropical forests, the many wide rivers and competition with native predators have been suggested as factors which have limited its spread (Westermann, 1953).

Like other continents, South America has received its share of exotic ungulates. About thirty years ago Red Deer and Fallow Deer were imported for aesthetic and game purposes from a German zoo and liberated on various estates between Temuco and Puerto Montt, Chile; they have reproduced and exist in semi-

confinement (Mann, *in litt.*). On the island of Lago Ranco, Province of Valdivia, wild herds of Red Deer have been reported (Peña, *in litt.*). Red Deer were also introduced between 1916 and 1918 by Pedro Luro in the province of La Pampa, Argentina, and they compete for food with domestic stock. They thrive in the region of the Cordillerana de Neuquen and north of Chubut, and compete strongly with the native Huemul (*Hippocamelus bisulcus*) and Pudu, and are a serious pest to agricultural interests (Crespo, *in litt.*). In Argentina, Fallow Deer have been introduced on various estates in the vicinity of Buenos Aires, but they have not become serious pests (Cabrera & Yepes, 1940; Crespo, *in litt.*). Axis Deer (*Axis axis*) have been introduced in the province of Santa Fé in Argentina (Crespo, *in litt.*) and on farms near Belo Horizonte in Brazil (Maia, *in litt.*); they are in semi-confinement and exist in small numbers. American Elk (*Cervus canadensis*) have been imported to Argentina, according to Murie's (1951) map, but whether these animals were liberated or confined is not known. The report of the introduction of the Bush-Pig (*Potamochoerus*) to South America by the early slave-traders (Simoons, 1953) is viewed with

doubt, for the observations are probably confused with descriptions of the native peccaries. Several mammals have been transferred from one part of the continent to another, occasionally with unfortunate results. The Kinkajou (*Potos flavus*) was introduced (from northern South America?) to the Isle of Juan Fernandez, Chile, "for the purpose of eating the rats which exist there (!), but today is a serious danger for birds . . . destroying them." (Peña, *in litt.*). Two kinds of Armadillo (*Euphractus sexcinctus* and *Zaedyus pichiy*) have been recorded as introduced as pets from Argentina (as early as 1847) and established in central Chile (Osgood, 1943). Correspondents (Mann, Peña) have failed to confirm the existence of these two animals in the wild state in Chile, and doubt the veracity of the records. Seemingly, if these armadillos are established in Chile, they are neither numerous nor widespread. The introduction of several pairs of coati (*Nasua* sp.) and of a mustelid (*Vison* sp. [*sic*—the mink?]) about 1940 in the vicinity of Lago Todos Santos, Chile, seems to have been unsuccessful, for these animals have not been seen again (Mann, *in litt.*). It is gratifying to learn that some South Amer-

TABLE 3: MAMMALS INTRODUCED OR TRANSPLANTED IN SOUTH AMERICA

Common Name	Scientific Name	Year(s) of Liberation	Country or Place of		Reason for Introduction
			Origin	Introduction	
A: Successful introductions:					
European Rabbit	<i>Oryctolagus cuniculus</i>	1880	Europe via Falkland Is.	Tierra del Fuego	Food
European Hare	<i>Lepus europaeus</i>	1880	Europe	Argentina	Food
		?	Europe	Brazil	
Red Deer	<i>Cervus elaphus</i>	1920s	Germany	Chile	Sport and
		1916		Argentina	Aesthetic
Fallow Deer	<i>Dama dama</i>	1920s	Germany	Chile	Sport and
			Europe	Argentina	Aesthetic
Axis Deer	<i>Axis axis</i>	?	?	Brazil	Sport and
			India	Argentina	Aesthetic
Mongoose	<i>Herpestes auropunctatus</i>	After 1872	India via West Indies	British Guiana	Rat control
B: Successful transplantations:					
Six-lined Armadillo	<i>Euphractus sexcinctus</i>	?	Argentina	Central Chile	?
Pichiy	<i>Zaedyus pichiy</i>	1847	Argentina	Central Chile	As pets
Kinkajou	<i>Potos flavus</i>	?	Northern S. America	Isle of Juan Fernandez, Chile	Rat control
C: Unsuccessful transplantations:					
Coati	<i>Nasua</i> sp.	1940	Northern S. Amerca?	Lake Todos Santos, ... Chile	
Mink?	<i>Vison</i> sp. ( <i>sic</i> )	1940	?	Lake Todos Santos, ... Chile	



duction of foreign animals: "In the past few years strict government control has been exercised over the introduction of new animals, paying attention to the evident danger which these animals signify for a country of so labile a biotic equilibrium as Chile, whose flora and fauna are, for the most part, of ancient stock and therefore very susceptible to destruction by modern competitors." (Mann, *in litt.*).

#### *Australia:*

Australia furnishes one of the best examples of the destructive effect of exotics. Introductions, both of the rabbit and other mammals, have had results disastrous both to the native fauna and to man himself.

Free from the controlling factors of their original habitat, European Rabbits attained incredible numbers. They converted millions of acres of good agricultural country into semi-desert by denuding the plant cover and by girdling trees. This resulted not only in a decreased carrying capacity of the range for domestic stock, but also in the rapid disappearance of many specialized marsupials which could not stand the competition. Some marsupials have thus become extinct; others, fortunately, can live in areas too dry for rabbits, and some are arboreal.

Introduced foxes, ferrets, weasels, and feral dogs and cats have wrought havoc among the indigenous fauna. Generally the small marsupials with poorly developed defense mechanisms suffer severely from predation by these placental mammals which are more effective than the native marsupial predators.

Introduced deer have done less harm in Australia than in New Zealand, probably because the Australian habitat is less favorable for them. However, an appraisal of deer damage to forest reproduction and agricultural crops may prove them to be more destructive in Australia than has been supposed.

Table 4 lists the mammals which have been introduced into Australia.

Although further introductions are now rigidly prohibited, legislation regarding exotics already present does not always appear to be reasonable. The contradictory nature of the game laws is shown by the complete protection of deer in Queensland and their partial protection in Tasmania, while there are open seasons on kangaroos in both these states.

Australia's greatest curse, the European Rabbit (*Oryctolagus cuniculus*), was brought to Port Jackson with the first settlers in 1788, and presumably to the other early settlements in Australia and Tasmania. The progenitors of the

present hordes are generally believed to be the 24 released for sporting reasons at Barwon Park (near Geelong, Victoria) by Thomas Austin in 1859 (Stead, 1928). It is possible that domestic escapees may have become feral before 1859. Old records indicate many rabbits in Tasmania by 1825. They were also released on various islands at early dates as food for castaways. On many of these islands they did not prosper (Calaby, *in litt.*). There are none today on Kangaroo, King, Flinders or Cape Barren Islands.

Six years after the initial release, Austin had killed 20,000 rabbits on his estate and estimated that at least 10,000 remained. From Victoria, rabbits spread rapidly in all directions, unhampered by any natural controls. By the late 1870s they had crossed the Murray River into New South Wales; they soon populated thousands of square miles here and crossed into Queensland. In vain, thousands of miles of rabbit-proof fences were thrown up; poisoning campaigns killed not only large numbers of rabbits, but also livestock and native species (Stead, 1928). The rabbit has now apparently reached the limits of its range; it seems unable to penetrate the tropical zone, and is very scarce in the arid interior.

The rabbits' damage to vegetation is unbelievable. Vast areas of tree scrub have been cleared by debarking mature trees and eating young seedlings, and in turn unpalatable plants have developed to the detriment of the pastures.

The virus disease myxomatosis has recently proved fatal to millions of rabbits. Pathologists expect the virus and the rabbits to reach a dynamic balance, with the population of the latter at a less destructive level. It is hoped the virus will not attack other mammalian hosts.

Of the carnivores, the Dingo (*Canis familiaris dingo*) was almost certainly introduced by early aborigines or Malaysians. The native Tasmanian Wolf (*Thylacinus cynocephalus*) and the Tasmanian Devil (*Sarcophilus harrisii*) apparently were exterminated from the Australian mainland by competition with Dingos. Interbreeding of the latter with domestic dogs is increasingly common and has already eliminated "pure" Dingos from the more settled areas (Troughton, 1947).

The Red Fox (*Vulpes v. crucigera*) was introduced to Victoria from England in the 1870s for sporting purposes (Jones, 1925). It spread rapidly across the continent, but slowed to a stand-still in the last twenty years. It appears to be absent in the most northern part of the Northern Territory and on the Cape York Peninsula, and is still sparse in the Kimberley Division of Western Australia. Calaby (*in litt.*)



states that the fox's northern limit is beyond that of the rabbit. Foxes prey on most native mammals except the larger kangaroos, and they chase even these until the young ones fall out of the pouch (Stead, 1928).

Ferrets, stoats and weasels (*Mustela* spp.) were brought to Australia in large numbers to prey on rabbits, but proved to be extremely destructive to native birds and smaller mammals. No information was obtained regarding their present status.

The American Gray Squirrel (*Sciurus carolinensis*) occurs in only a few parks within the city of Ballarat, Victoria. These specimens are said to be descended from a single pair liberated about fifteen years ago. This species is also present in the city of Melbourne (Barrett, 1934).

The Indian Palm Squirrel (*Funambulus palmarum*) has become established near the Taronga Park Zoo in Sydney as well as near a local zoo at South Perth (W.A.). These populations represent escapees from the zoos, not deliberate releases.

The European Hare (*Lepus europaeus occidentalis*) was introduced in the 1870s from England to various sites in Victoria for sporting purposes. It is now well distributed over Victoria, New South Wales, parts of southern Queensland and South Australia. It seems not to present any great problem. Apparently it is not affected by myxomatosis.

Fallow Deer were first introduced into the Australian region by Captains Dumaresque and Kemp in 1829. Other species have since been introduced into Victoria (Bentley, 1954). Deer also occur in New South Wales, Queensland and Western Australia.

No less than seventeen different forms of deer were imported by the Victorian Acclimatization Society to their grounds at Royal Park from the 1840s to 1890. Those known to have been liberated in the wild are listed in Table 4. The Roe Deer failed to survive. Others which were introduced, but of which there is no record of their liberation, include the Luzon Sambar, the Moluccan Rusa, the Mule Deer, Chinese Water Deer and Musk Deer. According to offi-

TABLE 4: MAMMALS INTRODUCED INTO AUSTRALIA

Common Name	Scientific Name	Year(s) of Liberation	Country or Place of		Reason for Introduction
			Origin	Introduction	
A: Successful introductions:					
European Rabbit	<i>Oryctolagus cuniculus</i>	1788	England?	Several states	Hunting
European Hare	<i>Lepus europaeus</i>	1870s	England	Victoria	Hunting
Dingo	<i>Canis dingo</i>	?	?	?	
European Red Fox	<i>Vulpes vulpes crucigera</i>	1870s	England	Victoria	Hunting
European Red Deer	<i>Cervus elaphus</i>	1870s	. . .	Several states	Hunting
Sambar Deer	<i>Cervus unicolor</i>	1860s	?	Victoria	Hunting
Hog Deer	<i>Axis porcinus</i>	1866	?	Victoria	Hunting
Fallow Deer	<i>Dama dama</i>	1840s and later	England	Several states	Hunting
B: Partly successful, success unknown, or unsuccessful introductions:					
Indian Palm Squirrel	<i>Funambulus palmarum</i>	?	?	N.S.W., W.A.	Escaped from zoos
Ferret	<i>Mustela putorius furo</i>	?	?	?	Rabbit control
Stoat	<i>Mustela erminea</i>	?	?	?	Rabbit control
Weasel	<i>Mustela</i> sp.	?	?	?	Rabbit control
Axis Deer	<i>Axis axis</i>	1860-1870	?	Victoria	Hunting
Barasingha Deer	<i>Cervus duvauceli</i>	1871-1885	?	Victoria	Hunting
Rusa Deer	<i>Cervus timorensis</i>	1890	Indonesia	Victoria	Hunting
Sika Deer	<i>Cervus nippon nippon</i>	1890	?	Tasmania	Hunting
	and <i>C. n. taiouanus</i>	1850s			Hunting
Roe Deer	<i>Capreolus capreolus</i>	?	?	Victoria	Hunting

cial records from about 1884, several species of deer were introduced into the National Park, N.S.W. (Troughton, *in litt.*).

Most deer have failed to become established in the wild. In Victoria, the most common deer at present are the Sambar and the Hog Deer. In areas where Red and Fallow Deer do occur, they are not common. Little information is available on the browsing pressure exerted by deer; in localized areas, destruction of farmers' crops has been reported.

Sambar Deer (*Cervus unicolor*), first liberated in 1860, inhabit the hills northeast of Melbourne, and also West Gippsland. The northern and eastern limits of their range are uncertain, but they seem to persist despite considerable hunting pressure. On French Island, a population of Sambar traces back to a number that swam from the mainland in the early 1900s. The species is present in the Grampians and about Mount Cole in western Victoria. The National Park Guide of New South Wales, for 1893, states that Sambar were received via New Caledonia, but there is no indication of their ultimate survival.

Hog Deer (*Axis porcinus*) occur in the coastal areas of Gippsland in eastern Victoria, as far as the region between Nowa and Orbost. A herd is rumored to be present on the Murray River.

Red Deer (*Cervus elaphus*) occur in Victoria, New South Wales, Queensland and Western Australia. The Werribee herd in Victoria developed from six animals of Windsor Park blood imported in 1860. Stock from this herd was distributed throughout Australia and New Zealand. Another herd, introduced about the same time and owned by the Melbourne Hunt, was bred from Windsor Park and Knowsley Park stock; it contributed to the present Victoria population. In Western Victoria, Red Deer are reported from the timbered ranges about twenty miles south of Ballarat, west to Ararat, in the Wartook and Victoria valleys of the Grampians, and possibly in the Otway Ranges. In eastern Victoria, these deer are occasionally taken near Warburton and Gembrook.

Red Deer were liberated near Aston in New South Wales about 1918 and appear to have extended down the Bemm and Brodribb Rivers in Victoria (Bentley, 1954). They presumably also occur in the timbered hills along the Brisbane and Mary Rivers of Queensland. The New South Wales official National Park Guide, for 1893, refers to a donation of five Red Deer in November, 1886 (Troughton, *in litt.*). Their progeny appear to survive. Red Deer have been in the North Dandalup-Pinjarry area, south of

Perth, for about fifty years, and seem to be barely holding their own (Calaby, *in litt.*).

Fallow Deer (*Dama dama*) were introduced into Tasmania in 1829 and now represent the bulk of the deer population, although covering less than one-twentieth of the island (H. A. Cox, *in litt.*). Some of these were later shipped to Melbourne and elsewhere. Wild herds were mentioned in the ranges northwest of Bacchus Marsh, Victoria, after 1810. They are now found near Casterton, on the Murray River flats near Wodonga, in the Healesville-Norbethong area and in west Gippsland and the Dandenong Ranges. Hunting has greatly reduced the population in several places. In the Glen Innes district (N.S.W.), seven individuals gave rise to a herd of 1,000 by 1939; they proved very destructive, and shooting parties reduced the population to about 200. Much the same history took place in the National Park after 1884 (Troughton, *in litt.*).

Axis Deer (*Axis axis*) were liberated at Bunyip and Wilson's Promontory between 1860 and 1870, but now occur in Victoria only in the Grampians. Some were also liberated in Tasmania about 1834 (Cox, *in litt.*).

Barasingha (*Cervus duvaucelli*) were liberated in Victoria late in the Nineteenth Century and before World War I. A few seem to persist in the Mirboo North area, and possibly elsewhere in remote sections.

Rusa Deer (*Cervus timoriensis*) were released in 1890 from the Victorian Acclimatization Society's grounds at Gembrook, and were flourishing in several places in 1900. They are now occasionally shot in Gippsland.

Japanese Sika Deer (*Cervus n. nippon*) were imported from 1868 to 1887 by the Victorian Acclimatization Society, as were a number of Formosan Sika Deer. A number were liberated at Gembrook between 1887 and 1900. They have been reported on Wilson's Promontory.

#### *Africa:*

It is regrettable that no definite information could be collected regarding introduced mammals in most of northern and central Africa. Ellerman & Morrison-Scott (1951) speak of Fallow Deer in North Africa. Other possible introductions have gone unrecorded; various individuals questioned about this matter were unable to provide the requested data.

In Tanganyika, the Pemba and Zanzibar Islands are inhabited by two introduced forms: the Thick-tailed Shrew (*Suncus caeruleus*) and the Rasse (*Viverricula indica rasse*). The Indian Mongoose (*Herpestes auropunctatus*) has been introduced on Mafia Island (G. A. Swynnerton, *in litt.*).



Only three mammals are known as exotics in South Africa: the European Rabbit, American Gray Squirrel and Fallow Deer. None of these has spread very widely.

The European Rabbit (*Oryctolagus cuniculus*) appears to be the only introduced mammal in South Africa which potentially might become a widespread, serious pest. Fortunately, it is now restricted to Robben Island, an islet in Table Bay near Capetown. As early as 1656, rabbits were sent there by Van Riebeeck to provide food for vessels on their way to the East. These lagomorphs are stunted, and have become a pest by nearly eliminating all plants except inedible species. Consequently, the vegetation of the island is now characterized by its great uniformity (Adamson, 1934). Some years ago an attempt was made to exterminate the rabbits by digging them out, but this failed.

The American Gray Squirrel (*Sciurus carolinensis*) was imported into Capetown by Cecil John Rhodes, probably early in the present century. It was intended to fill a "vacant habitat," namely oak forests (also exotics), but seems to prefer the neighboring orchards (Bigalke, 1937a). A few pairs liberated on an estate on the eastern slopes of Table Mountain increased to occupy an area of land within forty miles of Capetown; this spread of range is well documented by Davis (1950). The species is still expanding its range, and seems likely to continue as afforestation proceeds and the pine plantations mature. This squirrel has become a nuisance to fruit growers, and was placed on the vermin list from 1918 to 1922, when rewards were paid for no less than 11,188 specimens. Destruction of seed has become a serious problem in some plantations. The chief factor limiting the spread of Gray Squirrels is the absence of tall seed-bearing trees; it therefore seems unlikely that they will extend much farther in Cape Province. The groves of oak and stone pine (*Pinus pinea*) in the western Cape satisfy their requirements. Although Gray Squirrels prey on small birds, they do not appear to affect the mammalian fauna (Davis, 1950).

The Fallow Deer (*Dama dama*) was introduced on the lands of the Vereeniging Estates Ltd. until about 1914. A nucleus herd was set free on a well-wooded area of some 3,500 acres, and the population has now increased to approximately 50 individuals. Fallow Deer also occur on two other estates (Bigalke, 1937b.)

#### Oceanic Islands:

Particular islands and island groups are discussed separately because they are inhabited by specialized faunas which, as a result of virtual freedom from predation, have developed few

defense mechanisms and in general are easy prey to aggressive introduced mammals. The environmental resistance encountered by exotics on islands is usually much less than in their countries of origin because of the availability of considerable forage as well as limited competition with native species.

New Zealand, the Caribbean Islands and Hawaii will be discussed separately. On the Galapagos Islands the introduced mammals which have a harmful effect on the native animals and plants are feral species (cattle, horses, donkeys, pigs, goats) and Black Rats (Lack, 1947). Rabbits (sp.?) have been responsible for a reduction of the native finch on Laysan Island.

*New Zealand.*—No other island group in the world provides such an interesting example of the havoc which introductions cause among native animals and plants as New Zealand. In no other area of comparable size have such a variety of mammals been introduced. Because of the long separation from other large land areas, a flora and fauna have evolved here which are very different from anything found elsewhere.

A major reason for the introduction of so many exotics was the virtual absence of native mammals, limited to only two species of bats. Maoris introduced a rat (*Rattus exulans*) and a dog before the arrival of white settlers. Since a meatless diet is unattractive to white settlers, Captain Cook and other early explorers took particular pains to import goats and other mammals. Still more exotics were introduced to provide hunting, furs for garments and controls for species overabundant due to lack of predation.

Wodzicki (1950) divides these exotics into two major groups: those which are widely distributed, e.g. Red Deer and rabbits, and those whose distribution has remained localized.

Many of the mammals in the first group may be considered serious pests. They have spread rapidly and become widely established by taking advantage of the large supply of available food and by considerable protection during the early stages of acclimatization. In some cases, a species first reached an excessively high population, and then declined to a more stable level after the exploitation of the reserve food. The continued spread of exotics has seriously affected the native flora as well as man's agricultural activities. In an attempt at control, as many as 100,000 deer have been shot in a single year.

With the possible exception of the Weasel, the mustelids and the hedgehog are well established throughout the country. Most of these were liberated for the purpose of controlling other animal pests, but they have had detrimental effects on the native and introduced

birds which considerably outweigh their beneficial activities.

Many mammals in the group of localized distribution have also proved troublesome. Their economic importance varies considerably. Chamois (*Rupicapra rupicapra*) and Tahr (*Hemitragus jemlahicus*) are dispersed over areas of many hundreds of square miles, while wallabies and several kinds of deer are restricted to relatively small areas.

When first introduced, each species increased in inverse ratio to the resistance by the environment. In some cases, this full resistance may not have been encountered until the species reached a very high population.

According to Wodzicki (1950), four periods of liberation of exotics may be recognized as follows:

1. From the settlement by the Maoris to the visits of Captain Cook,
2. From the time of Captain Cook's visit until 1840,
3. From the period of regular settlement until about 1900, and
4. The present century.

During the first period, the Polynesian cat and dog and the Maori rat were introduced; these species did no appreciable damage to the native flora and fauna. The second period brings the first intentional introductions of exotics. During the third period, white settlers profoundly changed the nature of the vegetation and also deliberately attempted to acclimatize many new animals.

Wodzicki tabulated exotic mammals according to the country of origin and the number of species that became established. Table 5 is modified from his table. Thirty-six per cent. have failed completely. The native rat and dog succumbed to the competition of their European counterparts. Two species of deer, after a slight initial success, are, so far as is known, either on the decrease (Moose) or completely absent (Mule Deer).

TABLE 5: COUNTRY OF ORIGIN AND TOTAL NUMBER OF MAMMAL SPECIES IN NEW ZEALAND (Modified from Wodzicki, 1950)

Country of Origin	Mammal Species	
	Liberated	Established
Europe and England	20	19
Australia	13	4
Polynesia	2	2
North America	7	4
South America	4	—
Asia	5	5
Africa	2	—
	53	34

Table 6 (modified from Wodzicki) tabulates the successful, partially successful, and unsuccessful introductions into New Zealand, with pertinent details.

*Caribbean Islands, West Indies.*—Considerable damage has been done to the autochthonous fauna and flora of the Caribbean Islands by introduced mammals. Unfortunately, this damage still continues. The Mongoose may be singled out as exceedingly detrimental; it has probably been instrumental in the complete or nearly complete extirpation of several species of mammals and birds. Many members of the indigenous fauna are continually falling prey to such introduced mammals as cats, dogs, monkeys and opossums. Table 7 lists the known introduced mammals of the Caribbean area. Many exotics introduced during the early days of settlement are unrecorded.

The Mongoose (*Herpestes auropunctatus*), the most destructive exotic animal in the Caribbean area, was brought from India to Trinidad in 1870 and to Jamaica in 1872, for the purpose of controlling introduced rats that were destructive in the sugar cane fields (Westermann, 1953). In later years the Mongoose was introduced in the West Indies. Its introduction on Martinique and St. Lucia was intended to reduce the numbers of the poisonous Fer-de-lance (*Bothrops atrox*), but this met with only partial success (Lewis, 1953). The Mongoose soon became well established and spread extensively; it now occurs on most large and moderately large islands of the Caribbean, but is absent on most of the smaller islets, which therefore serve as useful refuges for species decimated elsewhere.

The Mongoose multiplied rapidly in most places. The four males and five females released on Jamaica increased so quickly, and attacked the rats with such ardor, that in 1882 it was estimated they had saved the planters nearly 45,000 pounds annually. But as soon as the rats were appreciably reduced in numbers, the Mongoose began preying upon native mammals and birds that feed or nest on or near the ground, as well as on such small, harmless creatures as terrestrial snakes, lizards, toads and other amphibians, and land crabs. Eggs of birds and reptiles are also eaten. This havoc has greatly reduced the indigenous fauna and has all but exterminated several species of mammals, birds and reptiles. The killing of small domestic animals has caused serious economic repercussions. Thus, within twenty years after its introduction, the Mongoose had come to be regarded on several islands as the worst of all pests (Westermann, 1953). Furthermore, it has recently been



TABLE 6: INTRODUCTIONS INTO NEW ZEALAND  
(Modified from Wodzicki, 1950)

Common Name	Scientific Name	Year(s) of Liberation	Country of Origin	Reason for Introduction	
A: Successful introductions:					
Brush-tail Opossum	<i>Trichosurus vulpecula</i>	1858	Australia	Utility	
Scrub Wallaby	<i>Thylogale</i> sp.	1870	Australia	Sport and fur	
Swamp Wallaby	<i>Wallabia ualabatus</i>	1870	Australia	Sport and fur	
Black-striped Wallaby	<i>Wallabia dorsalis</i>	1870	Australia	Sport and fur	
Dama Pademelon	<i>Thylogale eugenii</i>	1870	Australia	Sport and fur	
Brush-tailed Rock Wallaby	<i>Petrogale penicillata</i>	1870	Australia	Sport and fur	
Wallaby	Species unknown	1903	Australia	Sport and fur	
Hedgehog	<i>Erinaceus europaeus</i>	1885	England	"Escapees"	
Stoat, Ermine	<i>Mustela erminea</i>	1885	England	"Natural enemies" of rabbit	
Ferret	<i>Mustela putorius furo</i>	1886	England	"Natural enemies" of rabbit	
Weasel	<i>Mustela nivalis</i>	1885	England	"Natural enemies" of rabbit	
European Rabbit	<i>Oryctolagus cuniculus</i>	Before 1838	England	Utility	
Hare	<i>Lepus europaeus</i>	1867	England	Sport	
Himalayan Tahr	<i>Hemitragus jemlahicus</i>	1904	Asia	Sport	
Chamois	<i>Rupicapra rupicapra</i>	1889	Austria	Sport	
Red Deer	<i>Cervus elaphus</i>	1851	England	Sport	
Axis Deer	<i>Axis axis</i>	1867	India	Sport	
Sambar Deer	<i>Cervus unicolor</i>	1875	India	Sport	
Wapiti	<i>Cervus canadensis</i>	1870	Canada	Sport	
Japanese Deer	<i>Cervus nippon</i>	1885	Manchuria	Sport	
Fallow Deer	<i>Dama dama</i>	1864	England	Sport	
White-tailed Deer	<i>Odocoileus virginianus</i>	1901	America	Sport	
Moose	<i>Alces americanus</i>	1900	Canada	Sport	
Common Name	Scientific Name	Year(s) of Liberation	Country of Origin	Reason for Introduction	Reason for Failure
B: Unsuccessful introductions:					
Marsupial Cat	<i>Dasyurus</i> sp.	1868	Australia	?	Only 2 introduced
Short-faced Bandicoot	<i>Isodon</i> sp.	1873	Australia	?	...
Ring-tailed Opossum	<i>Pseudocheirus peregrinus</i>	1867	Australia	Utility	Only 2 introduced
Kangaroo	<i>Macropus</i> sp.	1868	Australia	Sport	Only 6 introduced
Roan Wallaroo	<i>Osphranter erubescens</i>	1860-1870	Australia	Sport	...
Long-nosed Kangaroo	<i>Potorous tridactylus</i>	1867	Australia	?	...
Raccoon	<i>Procyon lotor</i>	about 1905	America	Escapees	Only 2 introduced
Chipmunk	<i>Tamias striatus</i>	1906	America	...	Only 2 introduced
California Ground Squirrel	<i>Citellus</i> ?	1906	America	...	Only 2 introduced
Guinea Pig	<i>Cavia porcellus</i>	1869	America	Stowaways	...
Bharal or Blue Sheep	<i>Pseudois nayaur</i>	1909	Asia	Sport	Only 3 introduced
Gnu	<i>Connochaetes gnou</i>	1870	S. Africa	?	Only 1 introduced
South American Deer	<i>Cariacus chilensis</i> (= <i>Hippocamelus bisulcus</i> ?)	1870	S. America	Sport	Only 1 introduced
Alpaca	<i>Lama glama huanacus</i>	1878	S. America	Sport	Only 3 introduced
Zebra	<i>Equus zebra</i>	1870	S. Africa	?	Only 2 introduced
Mule Deer	<i>Odocoileus hemionus</i>	1905	America	Sport	...

implicated as a reservoir of the virus of canine rabies (Seaman, 1952).

Two species of monkeys have been introduced into the Caribbean area. The Green Monkey (*Cercopithecus aethiops sabaues*) from West Africa was introduced on Barbados between 1673 and 1750; in 1903 it was found at only a few points where woodland persisted; it is still present today, in small numbers. The species was also introduced on St. Kitts and Nevis where it is still rather common. These monkeys prey on the eggs and young of birds, and are believed to have exterminated the St. Kitts Bullfinch (*Loxigilla portoricensis grandis*). The Mona Monkey (*Cercopithecus mona*), now present on Grenada, is native to the Cameroons and adjacent parts of West Africa and was possibly introduced by slave traders (Westermann, 1953).

The Opossum (*Didelphis marsupialis insularis*) was introduced from Trinidad into Grenada, the larger Grenadines, St. Vincent, St.

Lucia and Dominica, where it has apparently played a role in the nearly complete disappearance of the Ground Dove (*Scothrygon mystacea*) (Barbour, 1930). It is uncertain whether another species of opossum (*Marmosa mitis chapmani*), found on Grenada and some of the Grenadines, is native to these islands.

On Great Bahama Island one pair of Raccoons (*Procyon lotor*) from the Florida mainland were released about 1932; they are now considered a nuisance over the entire island (Sherman, 1954). It is conjectural whether or not another species of Raccoon (*Procyon maynardi*) was imported by man to New Providence Island in the Bahamas. *Procyon minor* of Guadeloupe, and *Procyon* sp. of Barbados, may also be exotics (Allen, 1911).

Several species of deer have been introduced on various Caribbean Islands. Whitetail Deer (*Odocoileus virginianus*) were brought to Cuba from Mexico and/or the southern United States, presumably about 1850. They formerly were

TABLE 7: SUCCESSFUL INTRODUCTIONS ON SELECTED ISLAND GROUPS\*

Common Name	Scientific Name	Year(s) of Liberation	Country or Place of		Reason for Introduction
			Origin	Introduction	
Opossum	<i>Didelphis marsupialis insularis</i>	?	Trinidad	Caribbean Is.	?
Mona Monkey	<i>Cercopithecus mona</i>	?	West Africa	Grenada	Pets
Green Monkey	<i>Cercopithecus aethiops sabaues</i>	1673-1750	West Africa	Caribbean Is.	Pets
European Hare	<i>Lepus europaeus occidentalis</i>	?	Europe	Caribbean Is.	Hunting
European Hare	<i>Lepus europaeus</i>	?	Russia	Islets off Oahu	Hunting
European Rabbit	<i>Oryctolagus cuniculus</i>	?	Europe	Caribbean Is.	Hunting
Black-naped Rabbit	<i>Sylvilagus nigronuchalis</i>	?	Venezuela?	Curaçao, Aruba	?
Agouti	<i>Dasyprocta aguti</i>	Before 1852	Brazil?	St. Thomas Is.	?
Red Agouti	<i>Dasyprocta punctata</i> ?	1890s	C. America	Cayman Is.	?
Mongoose	<i>Herpestes a. auropunctatus</i>	1870 and later	India	Caribbean Is.	Rat control
Mongoose	<i>Herpestes a. auropunctatus</i>	1883	Jamaica	Hawaii	Rat control
Axis Deer	<i>Axis axis</i>	?	?	Hawaii	Hunting
Mouflon	<i>Ovis musimon</i>	1954	Europe	Hawaii	Hunting
White-tailed Deer	<i>Odocoileus virginianus</i>	1850s	Mexico, U.S.A.	Cuba and other islands	Hunting
White-tailed Deer	<i>Odocoileus virginianus curassavicus</i>	?	Colombia	Curaçao	Hunting
Sambar Deer†	<i>Cervus unicolor</i>	During Spanish occupation	Philippine Is.	Guam, Rota	Hunting

\* Except New Zealand.

† R. H. Baker (1946).



more abundant, but have disappeared from many areas because of deforestation. A South American race (*O. v. curassavicus*) is thought to have been imported from Colombia to Curaçao. Deer of this or other genera have reached the Dominican Republic, Jamaica, U. S. Virgin Islands, Barbuda, Dominica, Grenada and possibly other islands (Westermann, 1953).

The European Hare (*Lepus europaeus*) and the European Rabbit (*Oryctolagus cuniculus*) have been reported introduced into Barbados, one of the Grenadines, and Guadeloupe (Allen, 1911): Another rabbit (*Sylvilagus nigronuchalis*) is supposed to have been introduced into Curaçao and Aruba.

Agoutis have been introduced into St. Thomas and the Cayman Islands. The species of St. Thomas is *Dasyprocta aguti*, probably obtained from Brazil prior to 1852 (Miller, 1918). The Cayman animal is a Red Agouti derived from Central America in the 1890s or earlier. It has rendered certain areas virtually useless for cultivation, and at present the Government pays a bounty of nine pence per head for its destruction (Swabey & Lewis, 1946).

Hedgehogs may have been introduced from Africa to Porto Rico before 1877, for the type specimen of *Erinaceus krugi* Peters (= *E. algirus caniculus*) was killed in Mayaguez, Porto Rico. Seemingly the species did not survive, for there are no recent records of them on this island.

*Hawaii.*—The Hawaiian Islands have only one native mammal, the Hawaiian Hoary Bat (*Lasiurus*). Introduced mammals have therefore exerted pressure mainly on the native birds, and there is little doubt that they have contributed to the decline of several species of land and sea birds. Depredations by certain mammals have been more serious in regard to eggs and young than to adult birds. It is likely that certain species of plants which served either as cover or as food, or as a link in the food chain of the nectar-feeding and insect-feeding birds, were destroyed or sufficiently reduced by introduced forms to contribute to the decline of certain native bird species (Schwartz, *in litt.*).

Table 7 includes the known introduced mammals of Hawaii.

Axis Deer (*Axis axis*) occur in limited numbers, but in dense concentrations, on Molokai, Oahu and Lanai. They cause damage by browsing where native flora still exists. Some legal hunting is permitted, but since the species is found on private land, no regulation of herds is attempted (Schwartz, *in litt.*).

A hare, believed to be of Russian origin (species unknown), is found on two small uninhabited islets consisting of only a few acres each,

off Oahu. The animal is not abundant (Schwartz, *in litt.*).

A herd of Mouflon (*Ovis musimon*) was liberated on Lanai during the summer of 1954, according to a report of the Committee on Fauna Conservation of the Conservation Council for Hawaii (1955).

The Mongoose (*Herpestes auropunctatus*) was introduced from Jamaica in 1883. It now occurs on all major islands except Kanai, Lanai and Niihau. It is abundant and the heaviest populations are found near sea level. The merits of the Mongoose in the control of rodents are doubtful; the sugar producers have their own regular program of rat control. In the past, futile attempts have been made to control the animals. Territorial laws prohibit transporting them between any of the islands of the group. The Mongoose has probably contributed to the destruction of some ground-nesting sea birds, as well as of the Nene Goose, Hawaiian Owl, Hawaiian Duck, Hawaiian Coot and Hawaiian Gallinule (Schwartz, *in litt.*).

#### INTRODUCED RATS, MICE AND SHREWS

The introduced Old World murids are among the most notorious of mammalian pests. The history of their spread (Silver, 1927) has been recounted so frequently that it need not be detailed here. They affect man's economy by eating and contaminating food, and they also carry epidemic diseases and parasites. As stowaways in ships, two species of rats and the House Mouse have been involuntarily spread by man throughout most of the world, including many scattered islands. These exotics are usually restricted to human habitations and their environs.

The rats concerned are the Norway or Brown Rat (*Rattus norvegicus*) and the Black or Roof Rat (*Rattus rattus*), several subspecies of which have been involved. The Norway Rat has by far the wider distribution and the greater abundance. It occurs in almost all coastal cities of the world, but also has spread widely inland. The Black Rat is generally considered to be less aggressive than the Norway Rat, and where the two compete it is often forced into the less desirable habitats. The Black Rat came to Europe in early times from Asia, probably on ships of the Crusaders sometime after 1191, and by the Middle Ages it had spread over most of the Old World. The Norway Rat arrived in Europe early in the Eighteenth Century, crossing the Volga in great numbers in 1727, reaching East Prussia in 1750 and Spain in 1800. The Black Rat and the House Mouse arrived in North America very soon after the first European visitors. The Alexandrine Rat (*Rattus r. alexandrinus*) is restricted to rather limited

areas on all continents except Australia. *Rattus r. frugivorus* has been recognized in recent years as part of the population in the United States.

Introduced rats are blamed for the destruction of small insectivores (*Nesophontes*) and native Rice Rats and Spiny Rats on the Caribbean Islands (Westermann, 1953). In Australia, the native rats are normally slower breeders than the two introduced species and have consequently been displaced in many places by these exotics (Troughton, 1947).

The House Mouse (*Mus musculus*), originating in Asia, has established itself not only around human habitations but also in the field, especially in the more moderate climates. In Africa and Australia it is now present over large areas, even very far from settlements. On the latter continent, as well as in North America, it is subject to irregular irruptions and during peaks of population it does tremendous damage to the vegetation. Introduced House Mice have developed new subspecies in several parts of the world. On the Faroe Islands, for example, four distinct subspecies exist today (Bourlière, 1954).

The House Shrew (*Suncus murinus*) has been spread by man throughout most of the southeastern Asian islands.

#### FERAL MAMMALS

Feral mammals have been transplanted by man as domestic stock or as pets, and have since escaped or been purposely released and then "reverted to nature" to various degrees. Although feral mammals may be of considerable biological and economic importance, they have received little attention from zoologists.

Domestic horses, cattle, sheep, goats, pigs, dogs and cats are now almost cosmopolitan in distribution, and also occur widely in the wild state. Many less known feral mammals such as buffaloes and camels populate certain parts of the world.

Feral ungulates provide meat in considerable quantities, and sport for the hunter. Some are considered harmful because of damage to the native fauna and flora and because they may harbor diseases affecting domestic stock.

The domestic goat (*Capra prisca*) undoubtedly has been the most destructive of feral mammals to native vegetation, particularly as it travels over all types of terrain and consumes all kinds of browse and herbaceous material. Feral goats occur on all continents, even in such places as the Scottish Highlands. In Australia they are well established in the dry interior (Calaby, *in litt.*). They are a serious problem

on many islands, such as New Zealand (Thomson, 1922), Hawaii and several of the Caribbean islands. A typical picture is that presented by Wallace (1880) of the island of St. Helena: "At the time of its discovery, about the beginning of the sixteenth century, it is said to have been covered by dense forest; to-day it is described as a comparatively barren, rocky desert. This change has been brought about by goats first introduced by the Portuguese in 1513, and which multiplied so fast that in seventy-five years they existed by thousands." Heavy browsing destroyed the vegetation, followed by erosion of the soil by tropical rains. The story is similar on Guadalupe Island, in the Pacific, where goats were released by Russians in the Eighteenth Century. Many species of plants and animals, particularly birds, apparently disappeared forever.

Feral sheep (*Ovis aries*) cause considerable damage to the forests on the Hawaiian Islands. Elsewhere they are not considered a menace by agriculturalists.

Feral pigs (*Sus scrofa*) are widespread throughout the world. In Australia, where they occur in almost every state, they are a problem for graziers (Pullar, 1953). In Hawaii they are sometimes a serious threat to wildlife, including the nearly extinct Hawaiian Goose (Schwartz, *in litt.*; Bryan, 1937). Man imported them to most of the South Sea islands and to the Galapagos Islands. In parts of New Zealand they are very destructive to vegetation. The pigs in the eastern part of the Indonesian Archipelago are presumably descendants of domestic stock, but in some places they may have hybridized with wild species. It is probable that the pigs on New Guinea are direct descendants of domestic stock.

Feral horses (*Equus caballus*) still occur in Australia, New Zealand, North and South America and Asia, and where they become too plentiful they compete critically for food with domestic stock and native wildlife. Feral donkeys (*Equus asinus*) are present in northwestern Australia and the Northern Territory (Calaby, *in litt.*). Some "burros" also are present in herds in places on the southwestern deserts of the United States (Anon., 1952b; Davis, 1953).

Feral cattle (*Bos taurus*) survive in fair numbers chiefly in Australia, where they are restricted to parts of Western Australia, the Northern Territory and western Queensland. They also are found in some numbers in New Zealand and in parts of the western United States (Linger, 1943). Indian Water Buffaloes (*Bubalus bubalis*) occur in large herds in certain valleys of northern Australia (Calaby, *in litt.*). Feral Water Buffaloes also occupy many



countries in southeastern Asia and the island of Marajo in Brazil.

Feral Camels (*Camelus dromedarius*) are now found in large numbers in the more arid parts of Australia (Calaby, *in litt.*) and of central Asia, and in small numbers in the Kalahari Desert of southern Africa (Cahalane, *in litt.*). Several attempts, prior to 1860, to establish them in Texas, Cuba, Jamaica and South America were unsuccessful (Goodwin, 1925).

Llamas (*Lama glama*) may have been introduced in Mexico as beasts of burden in the Sixteenth Century. None are present there today.

Reindeer (*Rangifer tarandus*), introduced into Alaska and Canada, have hybridized to some extent with the native Caribou (*R. arcticus*), with resultant genetic changes in each. These Reindeer have done considerable localized damage to Caribou range by overgrazing lichens (Cahalane, 1950; Hanson, 1952). A recent introduction of Reindeer into Scotland has failed, but the species has been successfully introduced to Iceland. The establishment of Reindeer in Tierra de los Estados is reported by Cabrera & Yepes (1940), but details of the results are lacking.

Among the feral carnivores, cats and dogs are the most destructive species. Both revert to the wild readily and, being efficient predators, they may do much damage to wildlife. Dogs and cats are responsible for the disappearance of several forms, particularly in the Caribbean area, in Australia and on small islands.

INTRODUCTION OF DISEASES AND PARASITES

A consequence of animal introductions generally not fully appreciated is the importation of diseases and parasites of which the exotics are hosts. Most diseases are more dangerous to a previously unexposed population, since no immunities have been developed. Introduced diseases may easily become established in native species, and may prove impossible to eradicate.

Two epizootic diseases, rinderpest and foot-and-mouth disease, are particularly destructive after introduction. Rinderpest, or cattle plague, introduced from Asia to Africa, killed many ungulates. The Cape Buffalo (*Syncerus caffer*), common before the disease was introduced, was almost extirpated in the first outbreak. Although methods of artificially immunizing domestic stock are available, these cannot be applied to wild game.

Foot-and-mouth disease, endemic to Eurasia, has been introduced twice with domestic stock to North America, but fortunately was extinguished in the United States and Canada. It is, however, present in Africa, Mexico and South

America, where thousands of wild ungulates have been killed in a futile attempt to combat it.

There are few data on the introduced parasites of exotic mammals and their possible influences on native hosts. Two pertinent papers dealing with the endoparasites of the European Rabbit in New Zealand (Bull, 1953) and of the Muskrat in Great Britain (Warwick, 1936) have come to our attention. These papers raise several interesting points, on which further information is desirable.

First, they indicate that parasites do get introduced, and sometimes several species at once. For example, of five nematodes and two cestode species found in the rabbits of New Zealand, three of the nematodes and both cestodes also are found among rabbits in Wales. The other two nematodes perhaps were acquired in New Zealand. The rabbit is one of the intermediate hosts for the two cestodes, which are carried in vesicles within the body, in the larval stage only. Another cestode, *Cittotaenia* sp., for which the rabbit is the definitive host of the adult stage, apparently is absent from rabbits in New Zealand, as well as in Australia. Possibly it failed to survive the long voyage from England (and the periods of confinement before and after the voyage) because of the absence of its only known intermediate host, a free-living oribatid mite.

At least two parasites, a cestode and a trematode, were introduced with the Muskrat hosts from North America to Great Britain. Two others might also have been introduced, had they not already been present in Great Britain. One other parasite was apparently acquired from the native fauna.

Second, it is possible for introduced parasites to be transferred to closely related or associated species of hosts. In North America, parasites of the Muskrat often are shared with the Meadow Vole (*Microtus pennsylvanicus*). Such an exchange might take place between introduced Muskrats in Europe and the Water Vole (*Arvicola terrestris*) or other species of voles. Table 8

TABLE 8: PARASITES SHARED BY THE MUSKRAT AND THE MEADOW VOLE

	Species of Parasites in the Muskrat*	Species also Present in the Meadow Vole
Trematodes	30	4
Cestodes	10	4
Nematodes	9	2

\* Data summarized from various reports.

lists the number of species of helminth parasites in North American Muskrats, and the number of those species which have also been found in the Meadow Vole.

Third, the more complicated the life cycle of the introduced parasite, the less likely is its chance for survival. Trematodes with a life history involving two or more intermediate hosts may not find suitable hosts in a new environment. Nematodes may be introduced with relative ease because many of them are transmitted directly from one final host to another, the intervening stages being free-living. Introduction of cestodes in the larval stages may be fairly easy, but survival depends upon the presence of a suitable final host (a carnivorous bird or mammal) in the new area.

Rausch & Schiller (1954) mention the introduction from Siberia to Bering Island of the larval stage of a possible Siberian cestode, *Echinococcus* sp., with its host the Red-backed Vole; the island foxes became infected with this cestode.

Little information could be secured about the transfer of ectoparasites with mammals. It seems likely that the tick, *Trombicula akamushi*, which harbors the rickettsial disease, scrub typhus, has been spread widely with introduced rats or other rodents. The Indian rat flea, *Xenopsylla cheopis*, which transmits bubonic plague, has also been spread widely with rats on ships into many parts of the world.

#### SUMMARY

For a variety of reasons, man has seen fit to transport mammals from one part of the world to another. These introduced forms have frequently failed to become established; when establishment did result, the exotics have usually failed to achieve the purpose of the introduction. Sometimes they have become serious economic pests, as well as exerting an unbalancing force on the local biotic equilibrium.

This paper, largely restricted to the problem of deliberately introduced mammals, discusses more than 200 cases of exotic species on different continents and islands.

Certain principles may be deduced from the study of introductions and transplantations of mammals. Some of these principles are described by Dice (1952); some principles and implications are discussed by Pierce (1956).

1. The result of an introduction is unpredictable; both the relative success with which it establishes itself and the amount of disturbance produced in a community through its presence depend upon the newcomer as well as upon the composition of the invaded community. The

more specialized a species is, the more difficulty it usually encounters in becoming established, and the less likely it is to become a pest.

2. No exotic mammal is identical in its various requirements with any native member of a community; this results in conflicts and causes numerous readjustments, often detrimental, in the ecologic organization of a community. One result is the reduction or elimination of certain native species. Established exotics may supplant closely related native species, often because they have a higher reproductive potential.

3. When an introduced species differs greatly in habits from existing members of a community, it may produce serious changes in the entire community. Thus goats introduced on certain oceanic islands have caused the virtual annihilation of vegetation and the consequent disappearance of many native forms. Mammals which are apparently harmless in one area may become serious pests in another. For example, the Phalanger is innocuous in Australia, but very harmful in New Zealand.

4. Genetic changes may occur in species after introduction to a new habitat. This is possibly due to the limited quantity of genetic material available when only a few individuals are introduced. For example, Mouflons introduced into Slovakia developed a new race expressed by different color of hair and shape of horns.

5. The transplantation of one form into the existing range of another form of the same species often results in the production of a mixed race, with sometimes serious complications, especially when the introduced form is in some respect less desirable than the native. In Czechoslovakia, for example, two introduced species of goat have interbred with the native Ibex, resulting in poor survival of the hybrids.

6. Some species change their habits in a new environment, often with serious consequences for existing communities and for man. The Raccoon-dog has apparently altered its food habits after introduction into the Caucasus; this is also the case with the American Gray Squirrel in South Africa and with the Formosan Gray-headed Squirrel in Japan.

7. An introduced species which establishes itself successfully seems to pass through two definite phases of population behavior: at first it multiplies rapidly and builds up to a peak population; thereafter it levels off to a point of moderate abundance, or may even become rare. The initial increase may be due to the lack of natural parasites or other controlling factors, which in time develop to again produce a stabilized community, but one with a changed composition.



8. Exotic species which become established as thriving populations usually do so at the expense of one or more native species. There is little evidence to indicate that the total supply of game will be increased by adding a new game species to a habitat already occupied by one with similar requirements; the habitat can support permanently only a certain population. Occasionally "vacant" niches may be occupied by exotics; this may be the case with the European Hare on farm lands in eastern North America, or with the Moose in Newfoundland.

9. The problems of chance introductions and of feral mammals are similar to those of deliberate introductions of wild species.

10. Control of a well-established introduction is extremely difficult. The only known case of the eradication of an introduced mammal which was distributed over a fairly wide range is that of the Muskrat in the British Isles.

11. There is evidence that parasites and diseases of introduced mammals are at least partly transferred with their hosts to new biota.

12. The evidence accumulated in this paper indicates that the introduction of mammals is a hazardous undertaking and that further introductions should be more carefully considered in advance. The introduction of a mammal for the sole purpose of controlling pests is almost certainly doomed to failure. Food habits are rarely so specialized that a mammal will feed entirely on the pest to be controlled. Few mammals introduced for sport have proved eminently successful.

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